Mechanical World — August 1958

THE WORLD AND EUROPEAN ENGINEERING

THE fall in commodity prices which has been a feature of the last year or so and which has been felt mostly by the less developed countries started in the first place as a result of slackening economic activity in industrial countries. This happened as commodities became increasingly available and while the prices of manufactured goods continued to rise. Most industrial countries bought more of the cheapening commodities, but the less developed countries did not receive enough to pay for their increasing imports from the industrial countries. This divergence of import and export trends reflected an inflationary condition in some countries and growing expenditure on economic development in others.

The latest United Nations World Economic Survey shows that the last few years have been characterized by a decline in the rate of growth of the gross national product in most industrial countries, by export trade following the same pattern, and, of more particular significance, an increase in idle industrial capacity. When the relationship of capacity growth to output growth has a marked effect it is clearly useful to have sufficient offsetting strength in the economy to sustain the level of activity. Wherever this reserve is insufficient there is bound to be fluctuation.

The change in world economy which has taken place in the last year or so has been widely interpreted as a reaction from the preceding period of economic expansion, brought about largely by a decline in fixed investment. This followed upon a proportion of idle capacity in some industrial countries. If, as this suggests, there is some element of a production cycle in this, then its origin can be traced to 1954 with its peak occurring in 1957. This suggests that the upward turn may occur no sooner than some time next year, but postulating an average advance in production (and certainly there are plans everywhere for a continuous increase in capacity) the upturn could well be at a level above the preceding low point.

The circumstances of the European engineering industries in the fluxion of world economy has been studied by O.E.E.C. and presented in a report which covers the same period and which provides a useful parallel. Engineering, metal production and metalworking comprise by far the largest sector in European industry. It employs 7½% of the working population and accounts for more than 12% of the gross national product. There are some 58,000 engineering establishments of which about 1,300, each employing more than 1,000 people, account for more than 45% of engineering employment; while less than 10,000, employing between 100 and 1000 people, account for about 40%, so the remaining 46,000 or so small plants employ the remaining 15%. During the course of the recent economic setback engineering has had a sustaining effect in that the rate of increase of output has been substantially more than that of European industrial production generally. It has maintained its level of employment better than have other industrial sectors and the supply and training of manpower remains one of its most important problems. Its costs have fallen in only a few items (non-ferrous metals, for instance) and the general cost trend has been upwards, and consequently the prices charged for engineering products have been rising too, though of late only moderately.

European engineering exports were about one-sixth of production, though the proportion from country to country ranges from 10% to 40%, and tends, under governmental encouragement, to increase rather more than internal demand, which has of late been arbitrarily restricted. By far the largest outlet is to the less industrialized countries which, as they become better equipped, will demand more of some things and less of others. Access of wealth and prosperity does increase the demand for engineering products however, and as long as the established centres keep abreast of technological development there is every prospect of a continued expansion in European engineering production.

LOG SHEET

Hydraulic Coal Mining

A completely new system of getting coal is to be tried out in a first experimental installation of hydraulic mining at Trelewis Drift Mine near Treharris, Glamorgan. In this process the coal is extracted by the power of high velocity water jets directed at the seam from a powerful hose, called a monitor, which can deal with high water pressures. When the coal has been broken down, the water jet is used again to clear the floor of the working place and to drive the coal along to the point of collection. In the initial trials coal will flow from the face into an open channel or flume and be carried to a screen where all coal above 2 mm in size will be separated and transferred to the normal conveyor belt system; the slurry (a mixture of fine coal and water) will be pumped up a 6-in. dia pipe to the surface of the drift mine where the fine coal will be removed and the clarified water returned to the system. If the trials prove successful steps will be taken to pump lump coal through the pipeline to the surface.

Hydraulic mining, which is practised extensively in Russia and to a lesser extent in Poland and New Zealand, gives a high rate of output per manshift: the equipment is easy to operate and to move, and although a considerable amount of power is required to supply high pressure water to the monitor, this can be generated on the surface where the plant is accessible and does not require expensive housing or flameproof electrical equipment. There is, of course, virtually no explosive danger with water power and apart from the pumping plant the equipment used for getting the coal is quite simple.

Mining at Trelewis is on the room and pillar system in which headings or roadways are driven through the coal leaving large pillars which can either be left for support, or partially or completely removed as operations move backwards down the headings. The drift is 1030 ft long and goes down at a gradient of 1 in 4 to a point where it meets the 5 ft 9 in thick Brithdir seam, which in turn rises at a gradient of 1 in 14 and extends to a distance of about 2000 ft.

Only the headings have been driven at this mine and it is proposed to start hydraulic mining on the pillars, starting from the highest point of the boundary and working backwards down the slope towards pit bottom, a method which will assist the broken coal to flow back more easily. The monitor will be placed at the end of a heading and its $\frac{3}{4}$ in. dia jet will be projected at each side of the coal walls in turn. The Brithdir coal is of medium hardness and although it contains some bands of stone, it is not anticipated that there will be any difficulty in removing it from the seam with the pressures available. It has been estimated that water pressure of 600 psi is sufficient to break down the softer coals and pressures up to 1200 psi for the hard and denser coals.

Only four men are needed to work each monitor, one to control the monitor and the others to attend to the pipes and flumes and fix supports. Russian experience suggests that production can be as efficient as in opencast mining, or between three and five times higher than with conventional methods, but there is no doubt that the only way to obtain reliable data regarding working pressures and the suitability of equipment is to proceed with pit trials.

The hydraulic mining project is a natural sequel to the Board's interest in the hydraulic transport of coal by pipeline. Work at two installations, one at Woodend Colliery in the West Lothians, where coal is being pumped up a vertical shaft, and another at Markham Colliery, Derbyshire, where the haulage of lump coal through a 1000 ft-long pipe on the surface is being studied, will continue. The main object of these two experiments is to develop more efficient methods of pumping and of transferring coal into a pipe line without losing pressure. The Trelewis project could be adapted for a hydraulic haulage system up the drift to replace the existing conveyors if the experiment in hydraulic mining proves successful.

The cost of the trials is estimated to be £48,000 over a six months period, and mining is expected to begin at the end of 1958.

Heavy-duty Blade Mill

The largest blade mill ever made at the Erith works of The General Electric Company Limited is now operating in the concentrating plant of The African Manganese Company Limited in Nsuta, Ghana, West Africa. Its function is to disintegrate the clay in the crushed ore so that it can be washed out prior to the concentration of the manganese mineral. The mill has a capacity of 400 tons of minus 5 in. ore per hour.

The mill consists essentially of an 8 ft dia rotating cylinder, 24 ft long, supported on eight rollers. Ore enters through a feed inlet at one end with about an equal weight of water. Rows of blades churn it up in its passage through the mill, so that it is discharged at the other end with all the clay disintegrated and the mineral scrubbed clean.

The shell is constructed of 1-in. mild steel plate in two sections, each 12 ft long, to facilitate transport to site. The two halves are bolted together at spigotted flanges, four fitted bolts being provided on the principal axis for accurate location. Liners of chromium steel, 2 in. thick, protect the interior, including both ends, from wear. The longitudinal liners are cast with rows of blades set at an angle to the axis. The effect of the blades is to tumble the ore in the lower half of the shell and at the same time move it forward towards the discharge end. Some of the blades, at irregular intervals, are set at the reverse angle in order to throw the ore back and produce a churning action. In this way the clay is broken up and scrubbed off the surface of the mineral during its passage through the mill.

At the discharge end are radial scoops which lift the disintegrated ore pulp on to a heavy central deflector of manganese steel. Thence the pulp is directed into a discharge trommel with circumferential blades for moving it forward out of the mill.

Round the shell are two roller paths of cast steel 4 in. thick, with faces 20 in. wide. They are each mounted on 16 steel bars to allow slight springing under load, and are supported in such a way as to permit slow creep round the shell. This

Fig. 1.—Blade mill for scrubbing and cleaning manganese ore

Fig. 2.—Interior of blade mill showing liners and blades

guards against deformation from continual harmonic vibrations produced by the gear train at certain spots round the circumference. Each roller path runs on two pairs of 21 in. dia rollers, each pair being mounted on an adjustable rocker assembly. Two thrust rollers are provided to keep the shell in position longitudinally. They are mounted one on each side of the bottom of the roller path at the discharge end of the mill.

The mill is driven by a spur gear round the shell with a face width of 12 in. This engages with a spur pinion forged integral with its shaft. A flexible coupling with spring-type membranes as the driving media connects the pinion shaft with the output shaft of 10/1 reducing gear, which is automatically cooled and lubricated. The input shaft of the gear is connected through a Vulcan-Sinclair scoop-controlled fluid coupling to a G.E.C. 500-volt totally-enclosed fan-cooled squirrel-cage motor, running at 1450 rpm, with an auto-transformer starter. The fluid coupling gives an infinitely variable speed of mill rotation up to a maximum of 18 rpm. In practice, the speed is usually adjusted within the range of 14 and 18 rpm. The coupling is also a useful adjunct for inspection and maintenance, as it can be used for inching the mill round to the positions required for servicing.

The roller paths and rollers, together with the gear wheel and pinion, are protected by dust-excluding guards with Perspex windows at strategic points. Roller bearings are fitted throughout the mill. Lubrication is effected by a hand-operated grease pump directly connected to each of the thirty bearings with a tell-tale for each to indicate whether the lubricant is reaching them. A few strokes of the pump about once per month are sufficient to ensure adequate greasing of the whole machine.

The total weight of the blade mill is 80 tons, but it was so designed that, for ease of transport overseas, no single part weighs more than 10 tons.

Compressed Air Equipment

Measured in terms of value, 1957 was a most successful year for the British compressed air equipment industry. The annual report of the British Compressed Air Society shows that deliveries by manufacturers in the year reached a record figure of over £21 million; the value of exports of compressed air equipment was higher than in any previous year and £½ million more than in 1956.

The value of deliveries of compressors and exhausters by U.K. manufacturers in 1957 was 11% higher than in 1956, but this increase was smaller than that for 1956 over 1955, which was 15%. Taking into account changes in prices, the 1957 increase probably represents a growth of 5% in volume of output.

The value of deliveries by U.K. manufacturers of pneumatic tools fell in 1957 to a figure slightly below that for 1956. The decrease is attributable to smaller deliveries of spare parts and accessories, rather than to complete tools, the manufacturer of which rose slightly in value although the volume of production probably fell.

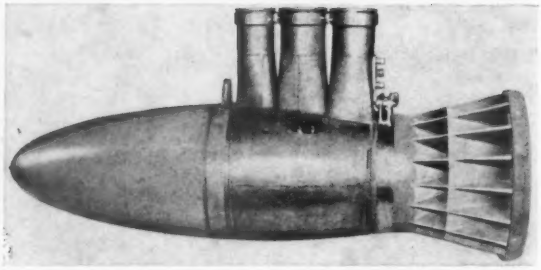
The value of paint spraying equipment produced was 7% higher than in 1956—a slightly smaller increase than in the previous year.

Non-ferrous Metals

The success attending the efforts of The British Non-ferrous Metals Research Association is indicated in its report where it is recorded that income from industrial members and total revenue each increased from 1955 to 1957 by about 25%. A new building is well advanced and this will largely be paid for by generous extra contributions from members.

Whilst enabling new lines of research to be undertaken, such as in the field of nuclear energy, instrumentation and the fatigue of structures, the new resources are being used mainly to provide urgently needed space for existing work. The foundry has been particularly congested in the past but the equipment is now being rearranged to make its use more effective.

The association, serving as it does the smelting, manufacturing and user industries, has an extremely varied programme.



Left, Fairey Rotodyne, world's first vertical take-off air liner. Above, Fairey Rotodyne tip-jet unit fitted with experimental silencer

Computors for Aircraft Industry

Of two new electronic digital computors which have gone into service in the British aircraft industry, one is a Pegasus computer working at the Brough Factory of Blackburn and General Aircraft Limited on problems of aerodynamics, structures, aeroelastics, test flight and wind tunnel data reduction, basic geometric design and data for tangent planing of wind tunnel models. The Pegasus will also be employed by the Blackburn Engine Division.

The second computor, a Ferranti Mark 1 at Armstrong Siddeley Motors, Ansty, is working on engine performance calculations, prediction of compressor and turbine characteristics, whirling speeds and disc stressing. This is the fourth computor to be installed in the Hawker Siddeley Group and brings the total number of computors in service in the British aircraft industry to fifteen.

The Fairey Rotodyne

The Fairey Rotodyne is now well advanced on its flight development programme. Because it is the first and only aeroplane of its type anywhere in the world, much of the work entails research into fields never before explored outside a wind tunnel.

The Rotodyne is a true V.T.O. airliner. It ascends vertically in the same manner as a helicopter and, having gained height, flies forward as a fixed-wing airliner. By doing so it overcomes the speed limitations of the helicopter and dispenses with the long runways needed for fixed wing airliners.

In appearance the Rotodyne gives an impression of being a combination of helicopter and airliner; and, in fact, it is both. It is much larger than any previous British rotary-wing machine, having a fuselage big enough to accommodate 48 passengers or five tons of freight. It has two turbine engines, giving adequate power for flight in complete safety with one engine stopped. And it has a fixed wing and propellers in addition to its impressive four-bladed 90 ft dia rotor. The reasons for this novel combination are best explained by outlining the manner in which the Rotodyne flies.

Each engine is a Napier Eland propeller turbine, the two engines together producing some 7000 hp. Before starting them, the Rotodyne pilot places the propellers in fine pitch, so that very little thrust is generated and minimum power absorbed. The propellers are mounted in the conventional manner on the front of each engine, but at the rear of the engine is an auxiliary air compressor which takes in fresh air from above the wing. As the Elands run up to speed these compressors are brought into action by means of a fluid-drive clutch. The air from the compressors is ducted through large pipes along the inner part of the wing and up to the hub of the rotor.

MECHANISED BOOKING OFFICE.—In the new mechanised booking office for the Euston electric line platforms this Multiprinter machine prints tickets on the spot and obviates the need for the usual rows of ticket racks. To operate the machine, which is the first of its kind at any London station, the clerk moves the printing carriage so that a cursor indicates the destination required, inserts a blank ticket, presses a handle and the ticket is printed in less than a second. In addition to printing and dating tickets, the machine records details of each issue for accountancy purposes. Ten large machines of this type are to be used in the future mechanisation of main line booking offices at Euston

Here the air is fed past rotary seals and then into the blades themselves, through a trio of pipes leading to pressure-jet units at the tips. These units operate like the combustion chamber of a jet engine. The compressed air is mixed with kerosene (also fed through a pipe inside each blade) and the resulting combustion at the tip of each blade produces a forward thrust which drives the rotor round. This very direct method of driving a rotor has many advantages. In particular it eliminates the mechanical shafts and gears which would otherwise be needed—and which, to transmit several thousand horsepower, would be tremendously heavy.

When the rotor is running at full speed the Rotodyne takes off vertically and climbs away as a helicopter, steering in the required direction by differentially altering the pitch of the propellers. As height is gained both propellers are gradually brought into forward positive pitch to accelerate the forward speed. At an appropriate height and speed the clutches are disengaged so that the air supply to the rotor dies away and the tip jet units are extinguished. Thus all the necessary engine power is transmitted to the propellers and the Rotodyne flies as a fixed-wing airliner, the rotor being left to "windmill" of its own accord.

As speed builds up the stub wing increasingly takes on the job of supporting the aircraft until, at the cruising speed of some 185 mph about 60% of the lift is provided by the wing. The resulting "unloading" of the rotor removes the most

critical of the aerodynamic restrictions and makes possible a speed approximately twice that of present helicopters. Moreover, the fact that the forward propulsion is accomplished by propellers and not by a rotor greatly increases the efficiency of the aircraft.

For landing the pilot merely goes through the same cyle of operations in reverse, finally letting down vertically with the rotor once more absorbing all the power.

Electronically Controlled Millers

Vertical milling machines using the electronic control system developed by E.M.I. Electronics Limited are already widely used in this country and overseas. Now the company, in collaboration with the Cincinnati Milling Machine Company of Cincinnati, Ohio, has developed a data control system suitable for use with large skin-milling machines of the type used for manufacturing large aircraft components. The first control system for a machine of this type has been built at the Hayes factory of E.M.I. for eventual delivery to the Air Material Command of the United States Air Force.

The basic E.M.I. electronic control system has only been slightly modified to meet the needs of the giant skin-miller, which has a work table measuring 30 ft by 8 ft. The Cincinnati machine has been specially designed to meet the requirements of the U.S. aircraft industry, and is controlled entirely by information prepared on punched cards.

The procedure adopted for compiling the punched card data depends upon the complexity of the operation to be carried out. Calculations for the smaller and simpler parts can be worked out on a desk calculator, but a computer is a valuable aid for more complex operations.

The machine's two 100 hp cutter heads can be operated in unison, with the direction of motion reversed on one axis, or independently. Tolerances as small as ± 0·002 in. are well within the control equipments capabilities. The conventional method of producing contoured parts on these machines normally requires a copy-tracing system with a 1:1 ratio template supported adjacent to the tool. The cost of the copy-tracing system together with the large template table needed for skin-milling machines is often as dear, or dearer, than the electronic data control system by which it can be replaced, thus refuting the criticisms that modern control systems are too costly to make their use on a large scale practicable.

Four E.M.I. control systems for the skin-miller have been completed to date and further orders have been received. Cincinnati is now using E.M.I. electronic control equipment on several types of its machine tools, which are sold both in the United States and throughout the world.

AUTOMATIC MICROSCOPE.—This Zeiss automatic camera-microscope has been installed at the Sheffield works of Padley & Venables Limited, makers of engineering cutting tools. It combines microscope, camera, exposure meter and other equipment in one unit. There are only two others in this country. Designed primarily for exacting scientific research work in industry, universities and hospitals, Padley & Venables will use it in examination of steel and tungsten carbide and quality control work

Esso at Milford Haven

The new £18 million refinery and marine installation to be built by Esso Petroleum Company Limited at its site near Milford Haven will process initially 4·5 million tons of crude oil per annum (3,500,000 gallons per day). The principal products will be petrols, jet fuels, diesel fuels and marine and industrial fuels. Like the Esso Refinery at Fawley, Hants, the new project will achieve a substantial saving in dollars. It will yield products which, owing to Britain's ever increasing demands for oil, would otherwise need to be imported from dollar sources (the actual saving will be over 40 million dollars a year).

The refinery's marine terminal will be capable of handling simultaneously two tankers of up to 100,000 deadweight tons each. This terminal can be expanded in the future as and when necessary. In order not to disturb the current and silt deposition pattern in the Haven the berth will be of open pile construction.

The most modern pollution control measures will be incorporated in the new refinery, including air cooling rather than salt water cooling for all major refining units. The company already has considerable experience in this respect from its refining operations on Southampton water. Its refinery at Fawley is the largest in Britain and in the Commonwealth and by the end of this year will have a capacity of 10½ million tons of crude oil (supplied mainly from the Middle East).

Mr. S. Colwyn Foulkes, O.B.E., Hon.M.Arch., F.R.I.B.A., a member of the Central Housing Advisory Committee and of the Historic Buildings Council for Wales, has been retained as consultant in the matter of the siting and visual presentation of the installations. Sir Percy Thomas & Sons of Cardiff have been appointed architects for the administration buildings.

The principal contractors for the refinery are Foster Wheeler Limited, The Motherwell Bridge and Engineering Company Limited, Wm. Neill & Son (St. Helens) Limited, Whessoe Limited, Geo. Wimpey & Co. Limited, and for the marine terminal, J. Mowlem & Co. Limited.

Hydro-generator Control

The first large underground power station to be built in the British Isles is at Glenmoriston where the North of Scotland Hydro-Electric Board have two water-driven turbo-alternators each of 16 MW capacity supplying power to the Highland Grid. The control equipment at the station is supplied from 110 and 50 volt storage batteries. The 110 volt equipment comprises a 400 Ah capacity battery of 55 cells of Pritchett & Gold open-top type NB.17, for control of the turbo-generators, the operation of switchgear, the closing and opening of a number of gates, and for the d.c. emergency lighting system. The 50 volt 40 Ah battery, consisting of 24 cells of P. & G. closed-top type CTX.9, is accommodated in a sheet steel cubicle and provides supply for general indications and for operating local and remote alarms. The unit is complete with the associated charging equipment.

Corrosion Testing as an Engineering Auxiliary

Despite the economic importance of corrosion preventative measures the methods available for obtaining results quickly (apart from the salt spray test) do not seem to be widely known. In this article the important methods of industrial—as opposed to research—corrosion testing are described and the obstacles and limitations indicated. Corrosion testing is essentially a laboratory technique, and for truly informative results it requires personnel fully conversant with the many pitfalls and skilled at examining and assessing corroded specimens. Both the preparation of the samples and the prosecution of the test can have an inordinate influence on the rate of deterioration of the samples

By D. J. FISHLOCK

CORROSION is a peculiarly large and complex subject, a very few years ago largely ignored by scientists although ever a nuisance and expense to engineers. Its rapid elevation to the status of an applied science is closely associated with the solution of very many of our basic corrosion problems, and the laying of a foundation of theoretical knowledge on which much future progress must rest. Unfortunately, to do more than to scratch the surface of this field is beyond most engineers who are, of course, primarily concerned with preventing the premature deterioration of their products and not directly with the complicated chemical and electro-chemical reactions involved. The engineer requires to know:

(a) Whether he can build his product from materials which give the required mechanical properties and will also withstand the influence of the environs in which it is required to work.

(b) Failing this, whether he can suitably protect the various parts of his product from premature failure by corrosion.

One obvious method, certainly the most reliable, of assessing the above points is, of course, to try the idea out under service conditions. Sometimes this is possible and practicable, always providing that the consequences of failure are not unduly serious. Usually, however, such a procedure would be inordinately slow, and the design probably obsolescent before a conclusive result is obtained. The alternative is to devise some way of accelerating any corrosive influences. Superficially this would appear fairly simple: if the component is destined for service in sea-water, a hotter, stronger saline solution is used in the test; if for service in an industrial atmosphere, an artificial atmosphere of sulphurous fumes is developed. This basically is the principle of accelerated corrosion testing.

In practice such tests range from the comparatively simple, such as those in which panels are suspended above a tray of water in warm surroundings and periodically sprayed with brine from a scent-spray, to the large, complex and costly apparatus used in artificial weatherings. Sometimes, if knowledgeably selected and performed, the simpler tests give results as reliable and rapid as the most expensive. In this article it is proposed to deal with a number of the best known tests, and the more promising new ones, pointing out their uses and limitations and the extent to which the engineer without ready access to laboratory facilities can make use of them.

First, however, a few notes on the samples for test. The testing of actual components is often highly desirable—and essential, of course, if it is required to observe, for instance, possible galvanic corrosion between dissimilar metals in juxtaposition. Even when it is a straightforward check on the durability of a finish, the use of actual components is often desirable since the coating will probably be far from uniform in thickness; an electroplated nickel coating, for example, may be three or four times as thick on some faces as on others, owing to a characteristic of plating solutions known as 'throwing power', while even sprayed metal or paint coatings can be quite uneven on a complex contour.

On the other hand, it may be impracticable to use actual components either because of their cost or size or quite often because they do not readily lend themselves to that most important and difficult facet of corrosion testing, that of assessing the extent of corrosion. In such cases test panels of the same material, with the same surface finish and in the same state of heat-treatment are needed—usually about 4 in. × 6 in. Such panels are often more difficult to prepare satisfactorily. Since they are unlikely to bear any relationship to the shape of the component it is often misleading to process them in the same way; in any case, the tendency will probably be to apply an unusually thick film just because they are test-panels. In electroplating, uniformity of the coating can be achieved by suspending the panel in an insulating four-sided box (e.g. of Perspex), with open ends at the top and at the side facing the anode: the sides of the box must be at least 1½ times the width of the panel. The panel can then be plated to the average thickness of the components, or if comparing different plated finishes, to the same depth on all samples. The edges and back will, of course, receive virtually no deposit, and must be heavily coated with a corrosion resistant lacquer, e.g. Lacomit, or waxed. Anodized aluminium and magnesium panels need no such precaution since the oxide films are uniform in depth; the same applies to chemical con-

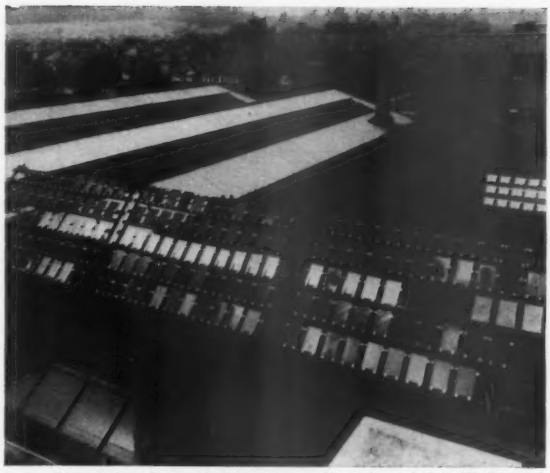


Fig. 1.—General view of atmospheric exposure racks on the roof of the Tin Research Institute. The test racks in position are mainly coated with electrodeposited tin alloys or with paint

The British Iron & Steel Research Association

Fig. 2.—Metal coated steel test panels on exposure to an industrial atmosphere at Attercliffe, Sheffield

version treatments such as phosphating, chromating, bronzing, etc. Dip-painted panels can be drained from one corner to give quite uniform coating, but paint films may justify more elaborate techniques. One is to pour the paint on to the panel whilst it is spinning at some 300 rpm on a horizontal table. The excess is thrown clear, and after 3 min a substantially uniform film, except near the edges, is formed. This technique does not, however, take account of the influence of the method of application in practice, e.g. by spraying upon the properties of the paint.

Sometimes special test samples can be used with advantage, one of the best for paint coatings comprising a flat steel panel to the centre of which is welded a piece of U-section steel channel. A panel of this type gives more information on the protected action of paint at edges, in corners, and on welds.

Whenever possible a thickness check should be made on the coating. There are several non-destructive instruments available although none is entirely satisfactory. They will reveal gross variations however, while some, under optimum test conditions, give results to within $\pm$ 15%. Thicknesses can also be computed from weight measurements.

Freshly prepared test samples must be handled with extreme care, the most important point being to avoid touching the sample by hand. Perspiration is a singularly corrosive fluid, containing a mixture of fatty acids, which has a devastating effect on many metals, particularly on matt or roughened surfaces.

Atmospheric exposure

In many respects this, the simplest of field tests, will be of great interest to engineers—particularly those primarily concerned with finishes. In this test suitable specimens, usually thin sheet metal panels, are exposed to the caprices of the climate for a period which, depending on the durability of the finish, may vary from a few weeks for a temporary soft-film protective to ten years or more for hot-dipped galvanized steel. Even with so apparently simple a test, however, there are many anomalies, and such tests need to be as well planned and conducted as those requiring elaborate test apparatus.

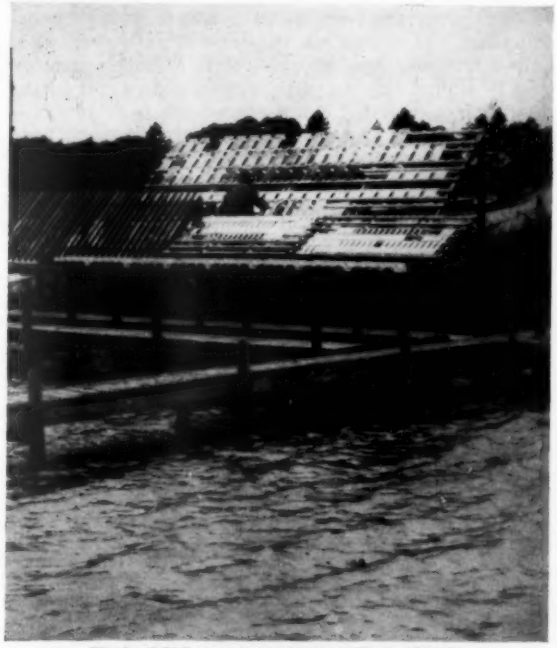


Fig. 3.—B.N.F. corrosion testing site at Hayling Island

In the first place, not only does our climate vary considerably during the four seasons, but the intrinsic corrosivity of the atmosphere is even more dependent upon the location of the test, i.e. whether in an industrial, marine, urban or rural environment. For comprehensive results, therefore, several test sites are recommended, each located where it can get the full benefit of the prevailing climate without being subjected to abnormal conditions, e.g. a nearby smoke-stack discharging sulphurous fumes. Occasionally, of course, location in extreme conditions such as in a railway tunnel may be informative, too. Care must in all cases be taken to prevent interference by human and other misleading agencies. Again, a daily record of climatic conditions is desirable, together with frequent examination of the samples. It is not unusual to find

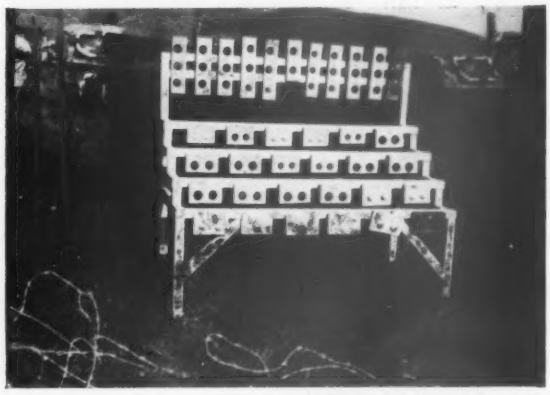
a sample which after a rapid initial deterioration in appearance reaches a *status quo* while a more slowly corroding one continues to deteriorate throughout the test. This daily climatic record should include such details as the temperature, relative humidity, rainfall (including duration), incidence of relative abnormalities such as snow, fog, mist dew, etc., and notes on the atmospheric contamination, i.e. SO_2 or chloride content of the atmosphere.

The usual method of exposing test panels is on a metal frame at 45° and normally facing South to gain the fullest influence of sunlight. The frames can be screened from rain, etc., if necessary, by a Stevenson meteorological screen, but with hard finishes it is usual to leave the frames fully exposed (Figs. 1, 2 and 3). A convenient way of constructing the frames is to use one of the slotted angle-irons on the market, with small plastic or ceramic rollers for retaining the specimens; these facilitate the removal of single specimens without general disturbance.

With regard to the disposition of panels on the frames, points to guard against include the possibility of one panel dripping on to another, and of panels restricting the circulation of air. Carefully conducted, however, atmospheric exposure tests, although decidedly long term projects, can be more informative and reliable than their accelerated counterparts. Their value can be gauged from the fact that every paint and metal finish research project, probably without exception, makes use of them, while in one case, the Kure Beach, North Carolina, exposure station of International Nickel Company first established in 1935 now has some 30,000 panels on test.

The salt-spray test

It is most unfortunate that this test, by far the most generally known of accelerated corrosion tests, is in many ways one of the least satisfactory. Evolved in



Aluminium Development Association

Fig. 4.—Aluminium test specimens exposed to salty attmospheres

America early in the First World War, the test has undergone very many modifications, mainly with a view to relating its results more closely with those obtained from service observations. Basically the test consists of exposing the specimens to an atmosphere of salt-fog. This is, of course, a very severe environment, having a combination of high humidity and a high concentration of the notoriously corrosive chloride ion; in consequence, most metals and finishes deteriorate rapidly, often in a few hours. Herein, of course, lies a major danger, since the rapid failure of a sample can lead to a snap and totally unjustified decision, while in actual fact the rate of deterioration may bear no relationship to that which would be found in service.

The original development of this test was connected with electrical construction work destined for exposure in a marine atmosphere. Early workers used a stone box with a glass lid which was inclined to prevent condensate on the lid from dripping on to specimens. This was fed with a 20% solution of sodium chloride through an atomiser actuated by compressed air at 6 or 7 psi. A baffle in front of the atomiser prevented the direct impingement of the spray. The samples, either panels or components, were suspended from a corrosion resistant frame, and the condensate from them drained off to waste.

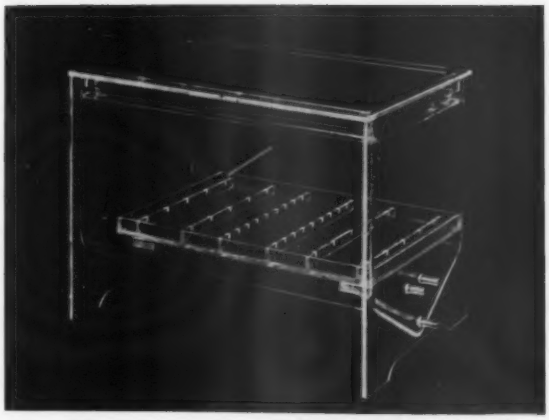
The apparent simplicity and speed of the test attracted many workers, and in particular the American Society for Testing Materials, to try and standardize

Tin Research Institute

Fig. 5.—Exposure to condensed moisture out of doors is carried out by fixing test panels to the underside of a horizontal heavy glass plate. One plate is being lifted for examination and a second plate can be seen in position

it so that it could be written into specifications. In actual fact, in the absence of an alternative it was often written in, notwithstanding the many limitations which were becoming apparent. Hence today it is the most widely known accelerated corrosion test. An outstanding illustration of the misleading results that it can give rests with the zinc v. cadmium finish controversy. When cadmium plating was first being bruited as an attractive and corrosion resistant finish for steel, salt-spray tests showed that thickness for thickness it was markedly superior to zinc plating, and despite a price difference of 10 to 1 or more in favour of zinc it was generally acclaimed. Subsequent experience has shown that except in marine and very humid environments zinc is generally superior.

The work which has proceeded with a view to fully standardizing this test has clearly shown that a host of variables influence results: these include the temperature of the apparatus, the size, shape and angle of inclination of the specimen, and its location within the apparatus, the air-pressure of the spray, rate of fog formation, and the pH and concentration of the brine. To control all of these factors fully requires a complex apparatus and time-consuming operation. Large and elaborate equipments—sometimes the size of a room—are in use, particularly in the U.S.A., but much smaller



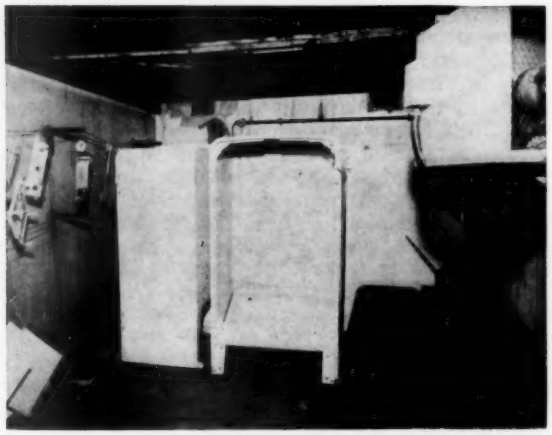
Research Equipment (London) Limited

Fig. 6.—Simple bench model salt-spray cabinet constructed entirely of Perspex

equipments, operated for making comparison rather than for testing to specification are generally favoured here. One of these, Fig. 6, is a small bench model built entirely in Perspex, with a water-sealed lid to prevent the escape of salt-fog. This is designed to hold thin panels supported by a Perspex frame, or a smaller number of actual components. An air-supply of some 5 psi is needed, which should be filtered and bubbled through distilled water to moisten it. Larger equipments are available as glass, wood or corrosion resisting metal boxes, often equipped with their own blower. Equipments of either of these types can be used to compare the corrosion resistance of different samples, providing that no attempt is made to compare the results of separate tests.

Among the applications of the salt-spray test might be mentioned its use for testing both metallic and organic finishes for their general resistance to marine atmospheres; here results are best compared with those obtained in several other tests, e.g. humidity and atmospheric exposure tests, to gauge all-round serviceability. Again, with organic coatings the value of the test can be enhanced by scoring the film with a scratch or cross to expose the base metal. The extent to which corrosion spreads back and undercuts the finish can give valuable information on the efficiency of the paint bonding system.

Nearly all electro-deposits are porous, owing to the co-deposition of non-metallic matter and gas, and to certain unexplained features of the build-up of their crystal structure. Beyond a certain thickness, which is very much a characteristic of the metal and the plating system in use, the pores do not extend right through the coating, but unfortunately this thickness is usually greater than that considered economically practicable; with nickel coatings on steel, for instance, it is probably about 0·002 in. whereas commercial deposits are about 0·001 in. or less. The significance of pores in a deposit is very much dependent upon the relationship of the deposit to the base metal electropotentially, Table I. If it is lower, or more cathodic than the base, then the latter will corrode at the bottom of the pores: if higher, or more anodic then the coating will corrode preferentially or 'sacrificially'; hence the utilitarian application of zinc and cadmium coatings on ferrous alloys.



James N. Kirby Holdings Pty. Limited

Fig. 7.—Hot room used for the performance testing of stove-enamelled refrigerator components. It is maintained thermostatically at 110°F (43°C), by heating water in the tank, bottom right, and circulating the moist air by the fan above it. Components are exposed for 720 hr at 110°C at 95-100% relative humidity

Table I.—GALVANIC SERIES OF METALS AND ALLOYS

Corroded end (anodic, or least noble)——

Magnesium
Magnesium alloys

Zinc

Aluminium

Cadmium

Steel and iron
Cast iron

Chromium-iron (active)

Ni-resist

18/8 Cr—Ni—Fe (stainless steel, active)
18/8/3 Cr—Ni—Mo—Fe (active)

Lead-tin solders
Lead
Tin

Nickel (active)
Inconel (active)

Brasses
Copper

Bronzes
Copper-nickel alloys
Monel

Silver solder

Nickel (passive)
Inconel (passive)

Chromium-iron (passive)
18/8 Cr—Ni—Fe (passive)
18/8/3 Cr—Ni—Mo—Fe (passive)

Silver

Graphite
Gold
Platinum

Protected end (cathodic, or most noble)——

The quest for modifying the basic salt-fog test has led to the development of one using a solution of 5% sodium chloride and about 1% acetic acid, pH 3·2 to 3·5, operating at 35° C. This has been evolved in particular for testing nickel/chromium electroplating,

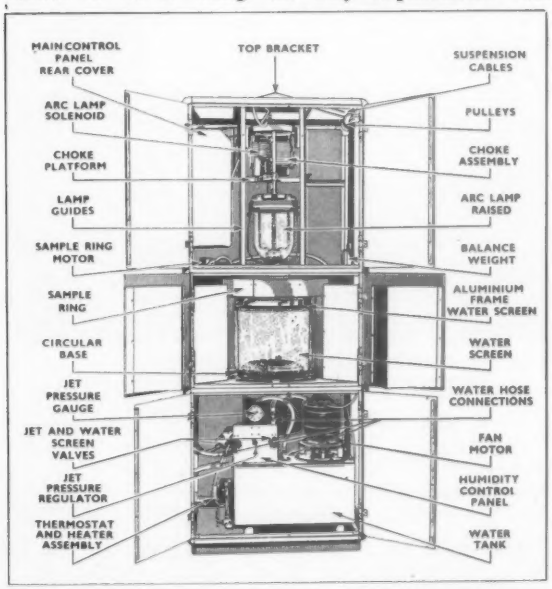
where the development of new nickel and chromium plating techniques have occasioned the need for a test which would prove their value as rapidly as possible. Very frequently it has been found that a new bright plating process, outwardly highly successful, failed unequivocally when subjected to a corrosion test, usually because of a crazing of the deposit owing to high internal stresses and low ductility.

The acetic acid modified salt-spray is undergoing extensive evaluation in the U.S.A., and thus far results indicate good correlation with atmospheric exposure tests on nickel/chromium. Results are available in two to four days, depending on the thickness of nickel present; a first grade chromium plate is resistant to 96 hr exposure.

Another and very simple test with brine is the A.R.E. salt-drop test. In this, specimens are carefully sprayed each day with a hand spray using a synthetic sea-water solution. They are then suspended over a trough of water and covered to maintain conditions of high humidity.

Humidity ovens

All galvanic corrosion requires the presence of an electrolyte. In the case of the salt-fog tests this is a strong sodium chloride solution which is highly conducting. Humidity tests use condensed water, a far less corrosive fluid as the electrolyte and the test is thus rendered much less devastating while the results can be more easily correlated with actual performance. In the simplest of the humidity ovens a high humidity, of nearly 100%, is produced at a moderately high temperature, usually about 50° C. If the temperature after some hours at this value is allowed to fall, very heavy condensation occurs. This phenomenon, incidentally, is one which is very commonly met with, and certainly near the tropics. A test of this kind can therefore be very simply performed, a lagged oven, suitably protected against corrosion, which can be heated to 50° C being the only requirement. The samples are hung inside above a tray of distilled water, and the temperature raised to 50° C and maintained for, say, 20 hr. It is then allowed to fall slowly to 27° C over the period of an hour, maintained at this temperature for 2 hr and raised to 50° C over the next half-hour. Fig. 7 shows a large humidity oven of this type.



Kelvin & Hughes (Industrial), Limited

Fig. 8.—The Fugitometer, an apparatus for testing under closely controlled conditions the fastness to light of dyes, e.g. on dyed anodised finishes on aluminium and magnesium

J. B. Marr & Company Limited

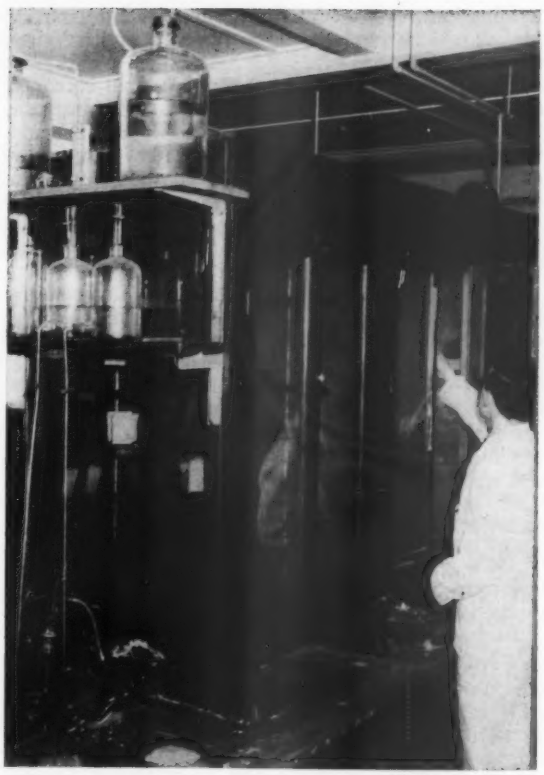
Fig. 9.—The Chemical Research Laboratories (C.R.L.), sulphur dioxide apparatus

This temperature cycling is obviously most conveniently carried out by time switches, and this, together with the incorporation of accurate temperature and humidity control and recording devices, and also such features as rapid cooling and irradiation, have led to the development of some very elaborate ovens. Such ovens are most desirable—nay essential for reliable specification testing, although the simpler and considerably cheaper versions are very informative for direct comparison.

In illustration of the cycles used in humidity tests, the following is used for testing switchgear on a large scale:

(a) Dry period, 12 hr at 60° C, 54% relative humidity.
(b) Artificial rain, 54 in./hr to cool plant to 22° C in 45 min.
(c) Humid period, 10 hr at 45° C, 100% relative humidity.
(d) Cooling to 20° C by fog spray or with CO_2 snow if necessary.

One of the more highly developed commercial ovens has a capacity of 14 cu ft. It is equipped with a temperature control to ± 0·5° C and with a recorder if required. The high humidity is generated through an electric boiler, the steam being uniformly circulated by a fan; this gives a relative humidity of virtually 100% with a 60° C rise above room temperature, and is



Tin Research Institute

Fig. 10.—Spray test chambers used for research work. The liquid sprayed is chosen according to the conditions it is desired to create. Spraying is intermittent, and the test panels allowed to dry off over night

accurately controlled by a wet and dry bulb thermometer. The humidity can also be recorded if desired. Further optional elaboration includes spray cooling of the oven for rapid fall in temperature, refrigeration down to 1·5° C, and irradiation by ultra-violet lamp. These various effects can be introduced in almost limitless combination and quite automatically by means of a cycling selector switch coupled to a time switch.

In the American Corrodkote test, considered one of the most promising of the new tests, the specimen is coated with a paste of kaolin mixed with water and various chemicals such as heavy metal nitrates and ammonium chloride. The parts are then placed in a humidity cabinet for one complete cycle after which the paste is washed away and the specimen examined.

Artificial weathering

Normal atmospheric exposure allows a number of quite distinct influences to affect the component; these include sunlight, rain, condensation, dusts, and gaseous atmospheric contamination. Many attempts, therefore, have been made to bring all these influences into a cycle, thereby giving a true accelerated weathering test. The principal drawback, of course, is the cost of a machine for producing perhaps a 6-stage cycle, while it has been found that there is a limit to the amount of acceleration permissible, owing to the formation under normal conditions of exposure of partially protective films and deposits.

Such machines have, however, achieved a measure of popularity, notably in the testing of paint films and of anodized aluminium films dyed with organic dyes (Fig. 8). In both cases rain and sunlight exert a considerable influence on the appearance of the coating. The two common features of nearly all such machines are periodic spraying or douching of the samples with distilled water, and exposure to ultra-violet light, the most easily absorbed and harmful radiation from the sun in practice.

In one machine the panels are rotated on a drum at 3 rpm. They are subjected to high-pressure spraying and irradiation from an arc lamp in succession. Such factors as the spraying pressure, flow of water, intensity of irradiation and speed of the cycle can all be regulated. Another machine conveys the test panels on an endless belt past the various artificial weathering agencies. These include a constant flow, low pressure brine spray, a low temperature heating zone, and a cold distilled water douch. The more elaborate versions of humidity cabinet also come into this category.

To avoid the expense, which may approach £1000, attempts have been made to devise artificial weathering cycles which are operated manually. An instance is a cycle comprising the following stages, which is repeated six times:

(a) Immerse in distilled water at 20° C for 4 hr.
(b) Expose to ultra-violet light for 2 hr periodically damping the paint film with distilled water.
(c) Period of exposure to ultra-violet radiation without damping.
(d) Immerse in distilled wated at 20° C for 2 hr.
(e) Hang under glass cover and circulate damp mixture of air and CO_2 for 24 hr.
(f) Ultra-violet radiation with periodic wetting for 1 hr.
(g) Ultra-violet radiation, dry, for 1 hr, raising the temperature to 50° C.
(h) As for (e) but using damp 1% SO_2 for 1 hr.
(i) Suspend in cabinet over hot water at atmospheric temperature of 35 to 40° C for 20 hr. Remove after 12, 14 and 16 hr, immerse in cold distilled water, cool to −5° C for 10 to 15 min and return to hot cabinet.
(j) Repeat (b).
(k) Repeat (c).

Sulphur dioxide tests

One of the most corrosive influences in the atmosphere of any industrialized country is sulphur dioxide, SO_2. This is produced through the combustion of sulphur compounds in fuels, particularly coal. In order, therefore, to simulate industrial atmospheric conditions a number of tests use a relatively concentrated SO_2 atmosphere in conjunction with high humidities, and these seem to offer the brightest hope at present of achieving a rapid corrosion test the results of which can be closely related to actual performance.

In the accelerated tests, of which several variations are now available, a humid atmosphere containing about 1% SO_2 is used. The C.R.L. sulphur dioxide test, which has been developed into a very compact and inexpensive piece of apparatus, comprises a large beaker containing a small amount of a weak SO_2 solution (Fig. 9). The base of the beaker is heated and continuous condensation is produced on the specimens, which are hung from a Perspex holder, by means of a lead cooling coil. The very corrosive conditions so engendered make this a very rapid test.

A German version is the Kesternich test, the apparatus for which consists of a small glass-panelled

cabinet into which an atmosphere of sulphur dioxide and carbon dioxide is introduced. The cabinet is heated by a hot-plate to between 50 and 55° C, when the gas mixture, together with steam, circulates around the sample by convection. A cycle is used of 8 hr at 50° C, after which the heat is turned off and the samples exposed overnight to the room atmosphere. By morning the dry samples can be examined before continuing with another cycle.

For large-scale tests, much larger cabinets have been devised although they do not differ basically from the small types. For convenience the test is usually performed at room temperature and with an SO_2 concentration of about 1% and a relative humidity of 95 to 100%. In the B.N.F. test of this type (Fig. 10) developed specifically for rapidly reproducing service conditions on nickel/chromium plating, 24 hr appears sufficient time to show up any sub-standard plating.

Special tests

A miscellany of tests remain with which the average engineer would infrequently come into contact. These include the total, partial and intermittent immersion tests. Of these the last is of greatest importance, especially where metalwork is likely to be periodically inundated, e.g. by tides. The rapid movement of fluids past metals also produces its own problems, and Chemical Research Laboratories have evolved their high speed rotor apparatus for investigating them. In this the specimen is mounted in an ebonite holder and rotated at 1500 to 2000 rpm, the equivalent of 20 to 25 knots. This has proved its value in evaluating paints destined for treating ships' bottoms; a 50-day test with the rotor was found to yield results closely similar to large-scale trials.

The coupon technique is an invaluable one if a sensitive balance is available. In this, small sheet metal discs, meticulously cleaned, are weighed and then located in a special holder in some unusually corrosive environment such as in a railway tunnel, fume duct, effluent pipe or the like. The loss of weight and the change in surface finish of different alloys when the corrosion products have been removed can give invaluable assistance in design. Coupons are usually too small for assessing the protective value of paint or metallic finishes, but a simple laboratory technique is available which uses them for comparing the various temporary protectives based on lanolin etc. In this, weak solutions of the grease are spotted on the coupons to give an extremely thin, uniform film. After drying, a drop of distilled water is spotted on each one. They are then left in a warm atmosphere, protected from dust, for 24 hr after which an assessment can readily be made.

There are also many special tests devised to investigate the combined influence of corrosion and mechanical forces on the metal, i.e. conjoint action. This type of deterioration includes stress and fatigue corrosion, fretting corrosion, cavitation corrosion and combined corrosion-erosion. These tests require mechanical devices to stress or otherwise affect the specimens, the device and specimen then being located in the corrosive environment.

Examination of specimens

Volumes have and can still be written on this highly skilled facet of corrosion testing, and the following remarks should serve as no more than a brief guide. Examinations, even of long term atmospheric exposure tests, should be made at daily intervals at first, since the initial deterioration may appear rather rapid. Care must be taken to distinguish between actual corrosion and the rather unsightly staining which often disfigures without otherwise materially affecting a finish; again, voluminous corrosion products often give the impression of severe deterioration when this is far from being the case. If the coating has been initially "damaged", e.g. by scratching or by an Ericsson cup test, to assist evaluation, the spread of corrosion from the damaged area is the salient factor.

The difference between anodic and cathodic coatings has already been mentioned, and corrosion of these are manifestly different too. Cathodic coatings corrode chiefly at the base of pores and a speckled appearance is usual—a crazing corrosion pattern may sometimes be encountered if the coating has itself crazed. Anodic coatings corrode preferentially however, and the deterioration is general, but there may be accumulations of corrosion product at pores or local thin spots. In either case a large magnifying glass or magnifying inspection lens can be of invaluable assistance.

Very often, corrosion takes place beneath an organic finish, and evaluation can only be made after the complete removal of the coating. This, of course, puts an end to the test, while it must be performed without causing further corrosion. Many solvents are available but two warrant mention. Paint can be softened and often largely removed by commercial paint removers such as those based on methylene dichloride or alternatively by a mixture of organic solvents such as benzene 50%, acetone 30%, alcohol 10%, ether 10%. Final removal is achieved with a brush or wooden scraper. Corrosion products can be removed from most metals, excluding zinc and light metals, by treating the specimen cathodically for 3 min in 5% H_2SO_4 at 74° C. A current density of 20 amp/sq ft is used, and an inhibitor is added to the solvent to minimize attack.

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MOBILE BELT CONVEYOR FOR VAN LOADING.—Reversible in operation the Rapistan aluminium Stevedore Junior is highly suitable for loading and unloading of vehicles, and can also be used for stacking a wide variety of goods. Being lightly constructed, the entire unit can be easily wheeled by one man and is readily adaptable for use in flexible conveying systems. The conveyor is made by Manufacturers Equipment Limited, Hull, and is available in lengths from 10 to 20 ft, with gravity feeders and adjustable guard rails as optional extras. A rough top belt supplied in either 10 or 16 in. widths, is fitted for positive incline conveying. When not in use, the unit can be stored in an upright position thus effecting considerable saving in floor space

Marquenching

Much has been written in the United States regarding a form of heat-treatment known as marquenching. In Britain, however, metallurgical research has suggested that this is a form of a previously known and more important treatment known as martempering. In the following notes some details are given of the marquenching process and its relationship to martempering is briefly discussed

THE development of a form of treatment to which the name marquenching has been given arose from the fact that some intricate objects of steel proved to warp or reveal cracks after they had been hardened in the ordinary way. Research appeared to show that a steel to be quenched and tempered would reveal the most satisfactory mechanical properties only if it could be given a wholly martensitic microstructure after quenching. Otherwise, the steel would lack tenacity or toughness, the property of strength combined with ductility that allows a steel to withstand fracture by shock, bending or twisting. Obviously, therefore, to produce a fully martensitic structure after quenching, the steel would have to have a suitably high hardenability.

In martempering, the temperature range involved, i.e. the bath temperature, lies between 65 and 150° C. In austempering, it lies between 260 and 430° C. In marquenching it is supposed to lie between 90 and 200° C., whereas in normal quenching by the conventional methods, the range is a mere 15 to 50° C.

In marquenching, the steel is quenched in hot mineral oil and then held at temperature until the heat has penetrated evenly over the whole mass, i.e. 'soaked', to use the technical term. It is then cooled in the air to normal room temperature. The beneficial influence of such a treatment on the microstructure of the material is achieved only if the cooling process is stopped at a temperature within or somewhat above the range of martensite formation, but below that at which the transformation of austenite to intermediate products and pearlite takes place. Marquenching is only completed when the soaking time has expired and cooling is resumed, and the degree of modification of the microstructure will be governed by the soaking period.

Oil is used in marquenching carbon steels because it gives the required final hardness without warping and distortion or the initiation of quenching cracks. Water, brine, the air-blast, are not only too severe in their quenching action on such steels, but also fail to give the necessary rate of heat transfer. Some steels, of course, cannot be oil-hardened, and marquenching is not applicable to these. The quenching oil should, however, be agitated either manually or mechanically to prevent local overheating of the bath and to ensure that the entire bath is at a uniform temperature.

Another advantage of oil is that it quenches rapidly at the start and more slowly later, and this is precisely what marquenching needs. Mineral oils are superior to organic oils for the purpose because they do not smell, do not readily oxidize, and do not ignite so easily. They must, however, include a proportion of high quality fats, carefully chosen. Oil also has the advantage in quenching that it does not produce a large temperature gradient. In other words, there is a smaller difference of temperature between one area of the steel being quenched and another. Thus, there will be a less sharp difference in temperature between the surface and the core of the piece. In consequence, the structural changes caused by quenching occur almost at the same time throughout the mass of the piece, so that internal stresses are fewer and milder, and therefore there is a smaller risk of volume change, cracks, unrelieved stresses, etc., caused by varying rates of thermal expansion.

Again, oil is less severe and has a smaller critical temperature variation than water so that it is easier to control the bath and to turn out a uniformly hardened piece. If there is any danger of distortion by quenching in hot oil, the work can always be straightened by placing it between clamp jaws.

Marquenching is said to produce three important results. If the bath temperature approximates to or exceeds the point of martensite formation, the microstructure resulting will be exactly the same as in martempering, unless the soaking period is greatly prolonged. If the temperature of the quench falls to below the point of martensite formation, then the resulting microstructure will be much akin to the martempered structure, but somewhat different because the martensite transformation is not entirely complete. (What this really means, according to British metallurgists, is that marquenching is merely imperfect martempering.)

If the bath temperature does not reach the range inside which martensite forms, the microstructure will be uniformily hard and free from distortion. It will be seen, therefore, that the bath temperature is the significant factor. Success is fully achieved, it is claimed, if the steel is not fully martensitic, but has some austenite in its microstructure, rendering it responsive to stress-relief, and reducing distortion and movement to a minimum. Moreover, the steel will be more uniformly cooled and structural constituents of troublesome character will not be formed, as they sometimes are in the true martempering operation. Consequently, it is claimed, parts of greater cross-section can be treated without loss of hardness than in the standard martempering operation.

Martempering is said to be unsuitable for certain steels for this reason. The exact results to be obtained from a specific steel depend on the type and condition of the quenching bath and the factors affecting the martensitic state, and also on the type of quenching equipment used. A final tempering is always necessary if the work is to give satisfactory results.

The process can be either continuous, batch or individual cycle, and usually existing plant can be modified as required. Soaking period is most important. Too short a soak means a sharp temperature gradient over the entire mass. Too protracted a soaking period causes delay and reduces output, with at the

same time the possible formation of unwanted structural constituents. Proper soaking gives uniform mechanical properties, absence of distortion, freedom from internal stresses, cracks and 'movement', and a smaller amount of retained austenite. In most works using this process a quenching period of eight minutes is regarded as the maximum.

The quenching temperature for maximum hardness must not be above 180° C. For maximum service life of the bath, minimum distortion and stresses, 150° C is recommended. A temperature of 200° C is held to be the absolute limit. Full hardness over the range specified depends on proper control of bath temperature, if possible by automatic regulation, to within + or − 2 to 3° C.

Newcomers to the method sometimes make the mistake of using too high a quenching temperature, i.e. one in excess of 200° C. Precise marquenching temperatures for the various steels have not yet been determined, but the reader desirous of pursuing the study further will find useful information in "Analysis of Hardenability under Marquenching Conditions" by Carmen, Armiento and Markus (Trans. Amer. Soc. Met. 1954, Vol. XLVI.P.1500).

The steel should not be removed from the bath under a period of six hours for cooling. When the steel has been quenched, it will have to be fully cleaned to remove oxidation products, and the most effective methods are spraying with an oil solvent and then with an alkaline spray, trisodium-phosphate spray, or rinsing in hot water. After being cleaned, the steel should be tempered by the standard methods within the range 150 to 180° C, allowing one to two hours per inch of thickness. In this way maximum toughness and ductility are achieved.

Marquenching is, as suggested earlier, confined as a practical heat-treatment operation to a relatively few steels, such as those from which automobile parts, ball bearings and carbon steel tools are made. The advantage claimed for it by its advocates is that it renders possible the employment of carbon steels where previously steels containing percentages of alloying elements in short supply could alone be used.

There are, it must be mentioned, a number of disadvantages. Some mechanical equipment must be obtained for circulating the quenching oil of the bath, or for its agitation. Moreover, since the oil of the bath tends to heat up in proportion as the number of quenchings increases, some equipment has to be provided to guard against or overcome fire. The steel has to be properly cleansed when removed from the bath so that there are inevitably limits to the size, shape and properties of the steels to which it can be advantageously applied. As a result, marquenching is used primarily for such steels as must on no account suffer warping and distortion, cracking, and the creation of heavy, unrelieved internal stresses.

For those steels to which it can be applied, it does to some extent reduce the degree of distortion, increase the hardness of the material as compared to that obtained by the standard quenching operations, and give a better performance to the steel in such respects as service life and load-carrying capacity. It also reduces the required number of finishing operations, lowers the proportion of scrapped parts, and makes assembly easier, as well as enabling smaller tolerances to be specified.

According to research, the response of a particular steel to marquenching is considerably affected by film effects known to exist, but behaviour of which is not fully understood. The steels for marquenching must be adequately responsive to hardening. Shallow-hardening steels are not suitable for marquenching.

References have been made to martempering, and it may facilitate comprehension of marquenching if a few concluding notes are given on the martempering process. This is a method of heat-treatment designed to minimize the residual internal stresses in a steel by quenching it in a hot bath at a temperature somewhat above or close to that of martensite formation, after which it is cooled gradually in air. Little martensite forms in the bath; the work is maintained at a uniform temperature throughout its mass; gradual cooling reduces internal stress and therefore distortion, warping and cracking are all minimized.

The steel must be hardenable to the degree required. A mechanized salt bath furnace is used, the bath being of low temperature type using salts soluble in water and readily removable by cleaning. The bath cools the work rapidly to about 250 to 300° C, or if the steel is of case-carburizing type, to 260 to 300° C. For splined shafts a temperature of 200° C is applicable whether the steel be of carburizing or direct hardening type, low manganese or low alloy type.

For tool steels, the range is 160 to 200° C, assuming these steels to be of tungsten-chromium-manganese and other non-distorting types. For tool steels in general, a range of 200 to 320° C is suggested. Martempering is specially advantageous when irregularly shaped parts made from high alloy steels are to be treated. The molten salt bath gives cooling rates restricting the process to oil- or air-hardening steels capable of being quenched.

Air-cooling eliminates severe temperature gradients. Steel castings can be martempered in molten salt baths or liquid baths at temperatures within the range 150 to 430° C. The efficacy of the process depends on the composition of the steel and the S-curve involved. The cooling rate in the bath is also of much importance. The properties obtained depend on the quenching period, and it is often possible, if the castings are small, to dispense with a tempering treatment afterwards.

Steels for martempering are chiefly those containing 0·4% carbon, but the process is in no way restricted to this type of steel.

Unspillable 2-Volt Cell

A completely unspillable Exide 2-Volt 8 Ah cell, type MFB9, has been produced by Chloride Batteries Limited, of Clifton Junction, Manchester, for portable light electrical duties such as portable instrumentation, lighting, aircraft and guided missiles. Filled and charged, this compact cell, measuring $3\frac{3}{16} \times 1\frac{5}{16} \times 4\frac{5}{16}$ in. high, weighs only 1 lb 5 oz and is capable of providing high discharge currents, with high terminal voltage, over a wide range of temperatures.

The container and lid of the cell are moulded in translucent high impact polystyrene, and the lid is a specially designed one-piece moulding cemented to the container to ensure a leak-proof joint. The vent incorporating an acid spray trap, is moulded integrally with the lid and is so designed to eliminate possible blockage by dirt or some object resting on top of the cell. Porvic microporous separators are used which permit the cell to be stored under suitable conditions in a dry, unfilled state for an unlimited period without deterioration.

The Fairey/Ferranti 3-D Miller

Very high speed aircraft depend for their performance upon structural components which must be made in one piece if they are to provide the necessary strength with a permissible weight. Such components can be forged or machined from the solid. The high cost of forging is compatible only with large scale production. The Fairey/Ferranti 3-D miller machines such parts from the solid, under precise electronic control, at speeds so high that the heat generated by cutting is confined to the chips, the work and cutter remaining unaffected

THE new 50-ton electronically-controlled Fairey/Ferranti three-dimensional high-speed miller is one of the most advanced machine tools in the world. It was designed and built by The Fairey Aviation Company Limited in conjunction with Ferranti Limited, Edinburgh, and is operating at the Fairey works at Heaton Chapel, Stockport, Cheshire. The machine has a table capacity 8 ft high and 28 ft long and machines slab material at speeds of up to 150 in. per min. It will produce components 30 times faster than any prevailing system or method in Europe.

The conception of the machine is the result of the demand in modern aircraft design for more speed, less weight and cleaner outlines. Since the advent of the gas-turbine the tendency towards higher and higher speeds for aircraft has led to a considerable amount of re-thinking in the design of aircraft structure. The problem simply stated, is a demand for more strength in less space and at less weight, combined with much greater accuracy of manufacture, in both the aerodynamic shape of the aircraft and in the internal structures where wide tolerances incur severe weight penalties. The main line of development has been towards integral construction; the change from multi-component structures with riveted or bolted assemblies to single-piece major components.

The original concept, particularly in the U.S.A., was for manufacture of these components from light alloy forgings of unprecedented size, and in America, a programme for the installation of heavy forging presses was prepared. The long-term nature of the manufacture of these very large presses created interest in the possibility of the manufacture of relatively small components from solid slab material, primarily as an interim measure, and secondly to deal with prototype work.

The experience gained in the U.S.A. from the performance of the first presses installed soon brought to light the severe limitations of the forging conception of integral construction.

1. Large forging dies are extremely costly and take a long time to manufacture.
2. The introduction of even a minor modification becomes a serious matter, both in time and money.

General view of Fairey/Ferranti 3-D milling machine

3. The close tolerances required could not be achieved by forging and more and more machining became necessary after the forging operation.
4. The distortion caused by stresses released during machining, could not be rectified.

The many difficulties encountered caused the U.S.A. to review their policy and the result was a drastic pruning of the heavy press programme and an increasing emphasis on machining from slab material. In the United Kingdom the enormous capital outlay necessary for heavy presses was not available and the slab machining technique was recognized as the only possible line of development for the British aircraft manufacturer. This resulted in parallel action on both sides of the Atlantic, but before any real development work could be initiated on shaping components, there were still two outstanding problems to be overcome in connexion with the slab material itself.

1. The distortion arising from stresses released during machining.
2. The reduction in transverse elongation properties as slab thickness is increased.

The first problem was resolved by carrying out a stretching operation on the slab in the direction of the grain. This process is not applicable to forgings, since a constant cross-sectional area is necessary in order to secure even stress stabilization throughout the material. Large stretching machines of several thousand tons capacity, capable of dealing with the maximum size of slab required, have now been installed both here and in the U.S.A.

The transverse elongation of the slab is a function of the amount and type of working the material receives in the process of manufacture and satisfactory values have now been achieved for even the thickest slabs by carefully controlled pre-forging operations prior to rolling.

Encouraged by the material developments, The Fairey Aviation Company initiated a research and

development programme on the manufacture of slab components. The overriding factor in any manufacturing process is the economic one and, in the case of machining integral components from slab, the governing factor is the enormous quantity of material which must be removed from the slab to produce the finished component, this being in the order of 90 per cent of the initial slab weight. It naturally follows that an investigation into the machining of light alloys was the first step.

Test equipment was assembled to study the effects of cutting at high speeds of up to 12,000 surface ft/min. An interesting feature revealed in metal cutting at these very high speeds, is that the heat generated in the process is contained in the cuttings produced and is not transferred to either the cutter or the slab material. This is most important, since cooling a high speed milling cutter is extremely difficult, and of course, heating of the slab would cause severe distortion. Metal pick-up and welding to the cutter was the major problem encountered, but this was resolved by injecting oil-mist directly on to the cutting face, from jets embodied in the cutter. With this technique a very high standard of surface finish was achieved.

It soon became evident that existing practice was not nearly approaching the full exploitation possibilities of light alloy machining and work proceeded with the development of a series of self-contained high speed spindles of up to 20 hp and 6000 rpm. Provided with suitable traverse movements, these could become economic cutting engines capable of exceeding, by very high factors, the efficiencies of conventional machine tools, which generally are designed primarily for steel cutting, with minor variations to embrace the light alloys.

The next stage in the programme was an investigation of the machine tool problems, in order to achieve optimum utilization. It was obvious from the results of the cutting test that hand-controlled machines were not capable of utilizing the full cutting potential and, since structural components must naturally be of diverse shape, a more sophisticated method of power control was essential.

A comprehensive survey was made of controlled machines in operation or under development both in Europe and in the U.S.A. In the meantime, a production component was selected and re-designed as a slab component, in order that comparative information could be obtained from its manufacture. In parallel with this, a machine was converted for hydraulic tracer control, in order, primarily, to gain actual experience of the control problem.

This machine, known affectionately as the "Green Linnet", has been producing components for the Fairey Gannet anti-submarine aircraft for a number of years.

A large variety of tracer control systems was available at this stage, mainly from the U.S.A. and the European mainland countries. The Massachusetts Institute of Technology in the U.S.A. were also operating a numerical control system which embodied some computer elements. The tracer systems were offered as basically accurate systems, where high accuracies could be achieved providing the machine to which they were applied was capable of utilizing the control information. The requirements of such a machine were that it should possess:

(a) A slide system having the lowest possible co-efficients of static and dynamic friction and free from the stick-slip phenomenon at all speeds.
(b) A drive system of extremely high stiffness, combined with low inertia and free from backlash under all drive conditions.
(c) Structural members of high mechanical stiffness with minimum mass.
(d) An efficient cutting spindle with a high degree of rigidity.

Deficiency in any of these features will bring about a resultant loss of accuracy, the first three items being the primary requirements of any piece of mechanical equipment controlled by a closed-loop servo system. Such a machine tool was not in existence and virtually nothing was as yet being made available by the machine tool industry of this country to meet the demands of the aircraft industry for such a machine.

Ball and roller bearing slides to meet the friction problems of the larger machine tools were already a feature of some smaller machines, and attempts to adapt these, and pads of low friction plastic materials, were made notably in the U.S.A. On the drive system problem considerable efforts were made by the oil companies to produce oils of high bulk modulus to overcome the fundamental lack of stiffness of ram systems, while the gearing approach was generally to utilize more accurately cut gears with reduced running clearance to minimize backlash. The structural problem was being met to a large extent by replacing cast iron with carefully designed light weight welded steel structures of comparable rigidity.

It was felt that these efforts fell far short of meeting the requirements and that machine tool design still lagged a long way behind the development of control methods. Theoretical calculations on drive systems indicated that, where relatively large masses are to be moved, a rack drive gearbox system was capable of a higher efficiency and stiffness to inertia ratio than screw systems or hydraulic rams, although the re-circulating ball screw correctly mounted is suitable where the load is small and the drive length relatively short. A design study was undertaken of a rack drive gearbox with two gear trains driving in opposition, incorporating a pre-loading device to eliminate backlash independent of gear tooth clearance. Gearboxes of this type have since been built and, under extreme test conditions, have fully met the performance requirements.

Much experimental work was done on slide friction problems where it was found that a form of pressurized oil system affording some measure of load relief would be superior to the low friction material pads and capable of carrying higher loads than the ball or roller system, where irregular surface deformation under load is the major fault. A suitable machine geometry was established to meet the production requirements and the estimated slide loads were plotted for a group of suitably spaced support points. These included all the dynamic and cutter load combinations as well as the static loads, the object being to provide a series of support pockets into which oil would be forced at a pressure slightly lower than that required to balance the minimum load occurring at that point so that the slide friction would be a function of the residual load

only and, in addition, slide contact would be maintained under all conditions. During the investigation into the method of controlling the large assortment of pressures required, it was realized that if the oil was allowed to flow continually from the pockets, causing the slide faces to separate, and if the flow was in some way limited, then the small variations in the slide gap could serve to control the pocket pressures and thus form a simple closed-loop servo system. The initial calculations based on a simple form of control showed that a slide system was possible where the sliding members would be completely separated by a control film of oil and yet have a stiffness comparable to that of the structural members when subjected to a varying load. Further test work was then carried out on an experimental rig embodying this system and the results obtained formed a basis for the design of the slides of the machine. The phenomenally low frictional results recorded on a full-scale test bed are quoted later in this report.

While the experimental work and design studies were in progress, research was being made in this country and in the U.S.A. into the electronic control of machine tools direct from programmed information. A programme control system offers obvious advantages over a template following system. Apart from the fact that no templates need be manufactured the programme system is capable of issuing advance information to the machine, the main feature being control of acceleration demands. In the case of a heavy machine tool operating at high speeds following a template, when the tracer reaches a corner or sharp change of shape on the template, the machine receives a demand possibly to stop travelling in the X direction and start moving along Y. This constitutes an infinite acceleration demand which cannot be met and the machine overshoots. This means that the tracer speed must be reduced for that operation to the point where the amount of overshoot occurring is within the permissible limits. Under programme control the acceleration demand can be automatically limited so that the machine can operate at full speed throughout the machining operation, decelerating only where a change of shape demands it. In this way the high machining speeds available are utilized economically.

Various programme control systems were investigated, the most advanced of these being the Ferranti digital system in which a computer is used to process the planning information, the machine control equipment being simply a servo system utilizing as its input the magnetic tape recording produced by the computer. The method of measurement adopted was the use of optical defraction gratings which are completely independent of the drive system and measure movement of the slides directly, thereby embracing the complete machine within the control loop. The more common approach was to control the machine up to the gearbox input side or the driven end of the lead screw and disregard inaccuracies occurring beyond that point.

Another outstanding feature of the Ferranti system was the simplicity of the programme information required. This is kept to a basic minimum, the computer handling all the necessary calculations in contrast to the other systems, which entail the laborious plotting of intermediate points, the spacing of which gives an approximate shape related to the accuracy required. It was quite clear at this stage that existing machines which were available, either with tracer or programme control systems, were inadequate to cope economically with aircraft requirements. In some instances speed was available, in others accuracy, but the two fundamental requirements never occurred together on one machine.

Knowing the requirements of the aircraft industry and with a sound background of mechanical development, Fairey's prepared a scheme for a machine tool capable of utilizing the full control possibilities of the Ferranti system, a machine to have a high degree of accuracy and which was at the same time an efficient cutting engine, thus making integral construction an economic proposition. This had been made possible through a proposal which had been put before the Aircraft Production Development Directorate of the Ministry of Supply and had received their support; a development contract was issued in late 1955 for the design and manufacture of the machine and included for full-scale testing of the various unorthdox features to be progressively conducted throughout the construction programme and continued until the machine was completed, when it would be subjected to a comprehensive series of performance tests.

The machine

The machine weighs 50 tons and has a vertical column travelling a distance of 25 ft along the bed, this forming the X axis of the machine. Mounted on the face of the column is the head carriage travelling vertically along the Y axis with a movement of 7 ft. The cutting head is fixed to a cross-slide on the head carriage and has an infeed movement of 12 in. along the Z axis. These X, Y and Z movements are servo controlled from the pulse information recorded on the magnetic tape.

The cutter serves the vertical worktable which is 8 ft high and 28 ft long and is formed of four cast iron slabs 15 in. deep mounted on three buttress supports. These stand on base castings fastened to the machine bed and allow the table to be set at a suitable distance from the cutting head, with a range of adjustment of 24 in. Running along the lower edge of the worktable is the chip conveyor which carries the swarf to one end of the machine to be deposited in containers. A series of hinged deflector plates on the conveyor can be closed to form a walkway along the full length of the table to facilitate component handling. Slide faces and other functional parts of the machine are fully protected by flexible covers against the ingress of swarf.

Hydraulic and electrical power supplies are enclosed in a separate housing away from the machine. The operator normally stands in front of the Ferranti control desk and behind him is the contactor panel containing the heavy electrical switchgear. On the platform at the base of the column is the hand control box mounted on a hinged pedestal which can be used for manual operation of the machine and setting up to component datums, two speeds being provided on each of the three movements, a normal operating speed for cutting and a pick-off speed at which single movements of 0·001 in. can easily be selected. The electrical cables and air supply lines are brought into the column on an overhead boom hinged from a wall stanchion and the hydraulic oil supply passed through flexible pipes encased in armour sheathing rolling in a metal trough built along the front edge of the bed.

The weight of the head carriage is balanced by means of a hydraulic cylinder inside the column. Two roller chains transmit the load, over pulleys on top of the column and through a double sheave on the end of the piston, the outer ends being anchored to the top of the column. This gives a two-to-one ratio, enabling a cylinder of short stroke to be used. Oil at a pressure of 1000 psi is supplied to the upper end of the cylinder from a reducing valve in the hydraulic supply line. On the upward stroke of the piston as the carriage moves down, the oil is exhausted to the return line through a spring loaded relief valve. The traverse speeds on the machine are infinitely variable up to the maximum of 150 in. per min on X and Y and 75 in. per min on Z. The normal operating range used in production is 100 to 150 in. per min for the roughing operations and 50 to 75 in. per min for the finishing operations.

The slide system

The method of slide lubrication used is a unique version of the hydrostatic pressure system in which the moving members are entirely supported on an oil film with no direct metal-to-metal contact between the bearing faces. An automatic metering device controls the pressure of the separating oil film in such a way that external loads applied to moving members cause an opposing force system to be set up in the oil film to balance the loads and maintain the rigid location of the slide. The system thus accommodates all the cutting and inertial loads encountered and the frictional forces are entirely viscous and independent of the loads on the slide. The main bed-slide of the machine under test with a 9 ton load gave the following friction force to speed relationship:

At 10 in. per min, force required = 2 lb
At 100 in. per min, force required = 20 lb
At 200 in. per min, force required = 40 lb

A reduction of the load from 9 tons to 1 ton caused a slide movement of only 0·0003 in. from the mean setting, the carriage still floating freely. This system is virtually free from wear, there being no metal-to-metal contact and so the accuracy and efficiency of the slides will be maintained indefinitely.

The drive system

It is quite common in a conventional machine tool drive system to find that the drive motor can be turned through a considerable number of revolutions before the machine begins to move, due to backlash between the mating teeth of the gearing and wind-up or elasticity in the gear shafts and bearings. If a controlled machine tool is to follow the control information with any degree of accuracy, then these conditions must be eliminated. The drive power for the Fairey machine is by high speed hydraulic motors of extremely low inertia coupled to specially designed gearboxes. The Ferranti standard ½ hp type gearbox is used on the infeed movement driving on to a re-circulating ball lead screw engaging with a double-nut system with spring pre-load. The larger gearboxes on the X and Y movements are of Fairey design and are twin-train boxes terminating in a pair of spur pinions driving on to a common rack. The gear loop is closed at the input end by an axially floating shaft with right and left-hand helical pinions engaging with the first gear in each of the two trains. Pneumatically loaded bellows apply an axial load to the floating shaft which results in a pre-load torque being applied throughout the two trains, equal to 110% of full load torque. Under conditions of no load the pre-load torque is equally distributed through the two gear trains and it is taken up by the driving train as the drive torque is applied. At full load the remaining 10% of the pre-load exerted on the non-driving train maintains the backlash-free condition. The axial float of the pre-load shaft accommodates any tooth ripple or eccentricity errors in the gearing and, over a period, automatically takes up tooth wear. The gears, shafts, bearings and mountings were designed for optimum conditions of high stiffness with low inertia and it is due to these considerations, combined with the virtual absence of slide friction, that the resonant frequency values recorded on test were: for the X drive with an 8½ ton column, 22 cycles per second, and for the Y drive with the 1 ton vertical carriage, 63 cycles per second.

The cutting head

The cutting head is a Fairey designed unit of 20 hp running at 6000 rpm and has been tested on the machine up to metal removal rates of 140 cu in. per min for face milling, 110 cu in. per min for end mills of 2 in. and 3 in. dia. The surface finish obtained at these rates was around 10 micro inches R.M.S.

The control system

Briefly, the sequence of operations in the Ferranti programme control system is as follows: The designer produces a drawing of the part to be machined, dimensioned with respect to a datum, each point being given three rectangular co-ordinates, representing distances in the X, Y and Z planes from the common datum. Points to be dimensioned are those where the two curves intersect, e.g. where a straight line joins a radius. From the drawing a planner prepares the machining programme specifying the route to be followed by the cutter and inserts information concerning cutter diameter and feed rate and also the shape of the path between the change points, a set of code symbols being used to denote a circle, an ellipse, a parabola or any other second-degree curve, the absence of a shape symbol denoting a straight line.

The programme sheet is then copy-typed on a Creed tele-typewriter which produces a typescript check copy and simultaneously a paper tape with a series of punched holes representing the programme information in binary code. This paper tape serves as an input to a digital computer which translates the information into a set of pulse-trains on a magnetic tape, the computer service being provided by Ferranti.

The three pulse channels on the tape control the X, Y and Z movements of the machine, each pulse representing a distance of 0·001 in. and the pulse-train recorded on the fourth channel provides a continuous check on the three control channels. When the magnetic tape is played back on the machine control desk, the command pulses are passed through the control equipment which transmits corresponding signals to the machine servos, so that the machine follows the pattern of movements recorded on the tape to produce the shape initially programmed.

Along the length of each axis of the machine is a glass grating, ruled over its full length with a pattern of fine dividing lines spaced with a frequency of 500 lines per inch. On the moving member a reading unit with a small section of similarly ruled grating placed at a slight angle to the long grating sets up a Moire

fringe pattern where alternative dark and light bands travel across the screen each time a line is passed. A group of photo cells scan this fringe pattern and transmit two pulses for each line counted, so that each pulse, again, represents a distance of 0·001 in. In the control equipment the tape signals are amplified and after passing through a direction discriminator are held in a binary store.

Feed back signals from the optical grating on the machine pass through a similar direction discriminator and on to the binary store where the input and the output signals from the tape and grating are then compared and any discrepancy between the two is passed through a mixing network, amplified and passed on to the electro-hydraulic valve which controls the oil flow to the hydraulic motors on the drive gearboxes. The command pulses are also passed through a rate meter which gives a voltage output proportional to the velocity demand. In the mixing network this voltage is compared to the feed back signal from a tacho-generator in the gearbox and, here again, the difference in voltage is amplified and fed to the electro-hydraulic valve. This velocity loop provides the coarse position control for the machine, the resultant velocity being maintained within ± 2% of the command velocity. The displacement loop signal is superimposed on the velocity loop signal and gives the fine position control of the machine within 0·001 in. Considerable emphasis has been placed on electronic reliability and the circuits are designed to continue functioning correctly even if the value of any of the components varies by as much as 30%. As an additional precaution a daily check drill is instituted where the screen voltages of all the valves in each channel are reduced in turn, so that any component approaching the marginal condition can be replaced before the day's work commences. This marginal check occupies only 10 to 15 min but the reliability of the equipment is sueh that it has never been found necessary so far to replace any components. Checking circuits are provided to ensure that the errors in the machine movements never exceed a pre-set level. The check channel pulses from the tape are compared with the sum of the feedback pulses from the X, Y and Z grating and if the discrepancy between these exceeds eight digits the machine stops. In addition to this, safety interlocks are also provided to stop the machine in case of failure of any of the services. Several refinements have been added to the control equipment supplied for this machine. The code symbol MCC-F appearing on a programme will automatically switch the control circuits to double pulse scale where traverse speeds of over 75 in. per min are being used and at the end of each programme the symbol MCC-W is used to stop the tape-deck. A mirror image switch has also been added to the control desk so that right- and left-hand components can be produced from the same magnetic tape.

Performance

A comprehensive acceptance programme was devised by the Ministry of Supply to test every aspect of the machine performance. A full alignment check was made and a series of test pieces machined and inspected for accuracy and finish. Time trials were conducted under full cutting load and complete functional checks made on all services. Extremely good surface finishes were obtained even under full load conditions, 8–10 micro inch r.m.s. at 110 in. per min, with a 3-in. dia end mill on a full face cut at 0·34 in. depth is a typical example. Dimensional accuracies of ± 0·002 in. were achieved on dimensions up to 18 in. with repeatability within 0·001 in. over four consecutive test pieces. An elliptical channel section frame 7 ft high, which entailed the machining of four elliptical paths, was produced with every dimension within 0·005 in., the part being programmed directly from the curve equations. All the test pieces were machined at the normal traverse rates quoted above.

It is too early yet to quote actual times against conventional method times, as the few components machined have not been produced in sufficient quantity by hand methods to achieve a settled production time. The time saving in relation to these is, of course, fantastically high, but records are being compiled and these indicate so far that original estimates of production rates between 10 and 30 times faster than normal will be borne out.

Future developments

Development work under the Ministry Specification is still proceeding on various features of the machine. Specially designed bearings will soon be ready for test for a 100 hp spindle to operate at 12,000 rpm which will raise the cutting capacity to 500 cu in. per min or even higher. Various aspects of angular control are being studied, the farthest advanced of these being a spindle adaptor carrying a variable angle cutter which will mill the changing angles normally encountered around the periphery of wing ribs. This can be achieved without any additional control equipment by locking the infeed movement and switching the Z channel over to the angular control. Design studies are also under way for a smaller version of the machine, tailored to meet the problems of milling high tensile steel components.

Pocket Radiation Monitor

A transistorized pocket radiation monitor, which has been designed by Philips Electrical Limited, Century House, Shaftesbury Avenue, London WC2, for the general survey, location and measurement of radioactivity, weighs only 1 lb 5 oz and its small dimensions, $6\frac{1}{8} \times 4 \times 1\frac{3}{8}$ in. enable it to be carried easily in the pocket. A built-in Geiger-Muller tube permits the instrument to be used as a probe for measuring gamma radiation and a separate mica end-window Geiger-Muller tube with a flexible lead can be plugged into the instrument for beta measurements. Two measuring ranges are incorporated; one for high and the other for low sensitivity using a meter calibrated in mr/h (radium gamma radiation) to indicate the radiation intensity. A small earphone can be connected for the audible detection of very low intensities. The all-transistorized circuit with printed wiring is power supplied by 3 V flashlight battery or two miniature 1·5 V cells.

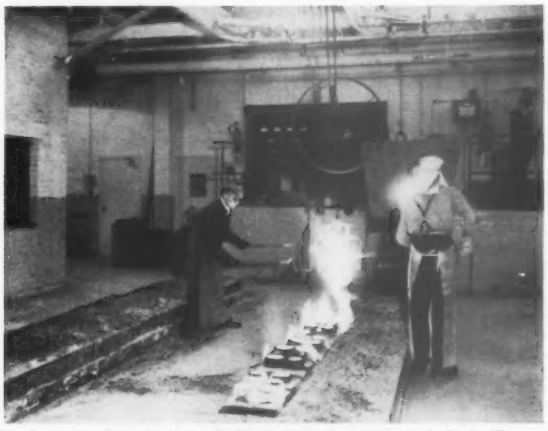
In general, the monitor type PW 4014 is suitable for use in all cases where the indication and measurement of radioactivity is necessary or desirable. Typical applications are geological survey, location of missing radioactive material, checking of radioactive contamination, dose rate measurements involving personnel, intensity measurements in laboratories where there is a radiation hazard and monitoring of special tracer experiments.

Precision Steel Castings

A newly equipped modern factory uses three moulding methods for producing steel castings to close tolerances and good surface finish

THE advent of precision methods has conferred economic and technical advantages upon commercial casting techniques, particularly as regards the higher duty metals and alloys. It is no longer necessary to machine such parts from the solid or to fabricate them from parts. It is now possible to have thin sections, surprisingly small tolerances, and a very minimum of machining (sometimes none at all) in alloy steel castings, and in addition a very desirable facility in design.

Precision casting as such it not new; it has been practised by the jeweller, for instance, for a long time: but its industrial application has occurred only in very recent times. Since 1951 Samuel Osborn & Co. Limited, of Sheffield, have been actively developing practical precision casting techniques in three forms, and with such success that a separate company, Osborn Precision Castings Limited, has been formed to make 'Socast' steel castings, and a new factory built for the purpose on an extensive site on the Holbrook Industrial Estate, some seven miles from Sheffield, where long-term development is planned for a number of the Osborn Group's activities.



Shank pouring from the monorail. The melting platform is at the back. The sand troughs in the foreground are used to hold shell moulds

The new factory accords well in layout and equipment with the connotation of precision. It is everywhere clean and light (indeed a test by an independent authority has shown the atmosphere in the factory to be cleaner than in the centre of Sheffield) and the arrangement is such as to facilitate the work being done and the control of the materials and processes. There are departments or sections for sand preparation, mould and core making, mould closing, pouring, cooling and inspection, cutting off, sandblasting, grinding, fettling, and heat treatment; there is storage for scrap, alloying materials, moulds, and castings; and the services provided include a compressor house, high frequency generator house, boiler house, shank preparation section, laboratory, plant and pattern maintenance department, pattern store, and offices, canteen, etc.

General view of new factory. Two bays and an annexe form the present building

The three processes used are shell moulding, the Osborn-Shaw process which uses a gelling refractory slurry, and the Osborn CO_2 block process in which CO_2 gas is used to harden a sodium silicate bond.

For shell moulding silica sand is mixed with resin in a machine which has a tumbling action. It is applied to the heat moulds in three twin-station machines* which have an aggregate output of some 84 moulds per hour. The half moulds are placed in racks to cool before being cored-up and closed by the application of adhesive and pressure. Two core-making machines provide some 60 cores per hour while 40 cores per hour are available from two manual stations. The moulds are stacked in sand troughs, with the sand drawn up around them, and are then ready for pouring.

The two melting units are supplied by two 200 kVA generators. One unit has one 1 cwt and one 5 cwt body, and the other has two 5 cwt bodies. An overhead monorail serves the scrap store, melting platform and pouring areas and the shank and ladle preparation area. The pouring is done from teapot type ladles and after pouring castings are transferred to pans on a roller track for storage. After sorting and release by the laboratory, the castings go to the fettling shop where heads are removed by friction band saw or abrasive cutting-off machines, and where initial shot blasting is done in a barrel-type machine. The castings are then batched in smaller pans and taken along roller tracks to four fettling lines provided with grinding and other equipment, and are then batched for heat treatment if this is required, and finally given a final shot-blasting in a cabinet type machine.

The heat treatment furnaces are arranged with chutes leading to quenching tanks in the floor in front of the doors. The water tanks are served by circulating pump, cooler and controlled water make-up. There are two high temperature furnaces for stainless and austenitic manganese steels requiring air cooling or water quenching; an annealing furnace for the normalizing and oil quenching of low allow steels and for hardening martensitic stainless steels (this furnace has an oil quench tank); an air-recirculating furnace with work basket; a twin pot salt bath for hardening without scaling, and a gas heated degreaser. The department is served by a monorail system.

* See "Production Shell Moulding", MECHANICAL WORLD, Jan. 1954, pp. 20–21.

The significant and relative features of the three processes as used in the new factory may be summarized as follows:

Shell moulding

(i) Stainless and high-alloy steels can be cast in thin sections that would be impossible by conventional processes. The dry nature of the mould and the speed with which the metal enters it, permit metal sections to be specified which a few years ago could only have been equalled by final machining.

(ii) Dimensional accuracy of the castings produced by shell moulding is such that expensive machining operations can in most cases be considerably reduced, and sometimes obviated. This is well illustrated by some link castings of a relatively thin section, and which interlock with one another without any machining.

(iii) High-alloy steels are particularly susceptible to hot tearing and the design of castings must be such that the susceptibility to hot tearing is minimized. With shell moulding, however, this tendency is considerably reduced.

Osborn-Shaw process

(i) The refractory is placed over the pattern in the form of a slurry, which ensures that the profile of a pattern is carefully reproduced in the mould. In this connexion, the Osborn-Shaw process has been found invaluable in the manufacture of plastic dies, extrusion dies, and similar shapes which have intricate surface contours.

(ii) The process lends itself to the manufacture of very intricate and complex shapes of varying section thickness. The degree of accuracy that can be achieved is not only dependent on the pattern equipment but also on the shrinkage of steel.

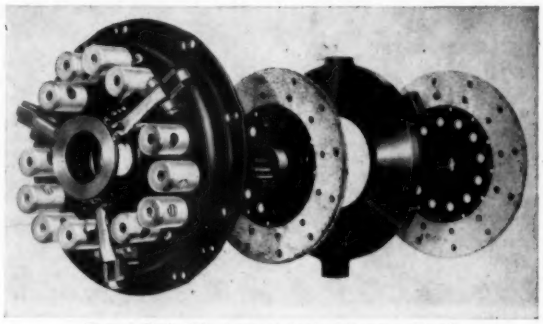
(iii) Metal can be poured into hot moulds, producing castings of thinner cross-sectional area than is possible by normal techniques. Sections of $\frac{1}{8}$ in. and $\frac{3}{16}$ in. are considered a practical proposition.

(iv) The greatest advantage of this process is its flexibility and value in connexion with development and prototype work. In many instances prototypes have been produced from wooden pattern equipment by the process before being transferred to the shell-moulding section for bulk production.

CO_2 block process

This has provided a means of raising the standard of steel castings produced by conventional methods, and a graded refractory mix has enabled precision castings to be produced which are impossible by shell moulding and which are cheaper by comparison with the Osborn-Shaw process. The process is invaluable for both jobbing work and for work done on a mechanized basis using moulding machines with boxes or snap flasks. A good finish is obtained, but not of such a high standard as by the Osborn-Shaw process. A very wide range of alloy steels can be successfully cast, in certain instances into hot moulds. The process lends itself to the development of prototypes.

The three processes make possible the manufacture of a range of castings in all grades of steel which would have been denied the steel founder less than ten years ago. Accuracies of $\pm$ 0·010 in. and $\pm$ 0·005 in./in. are regularly maintained on critical dimensions and surface finish is excellent and readily buffed up to a polish. Castings are produced which meet A.I.D. inspection requirements and cost, including inspection, is said to compare favourably with other methods of production.



Borg & Beck 10 in. integral clutch and power take-off

Single Pedal Controls Clutch and Power Take-off

This new Borg & Beck 10 in. integral main drive clutch and power take-off is suitable to those applications where it is desired to provide independent control, from a single pedal, of the main drive to the wheels and the power take-off. Briefly, the unit consists of two separate and independent clutches mounted in tandem within a single robust pressed steel cover, which is bolted to the flywheel in the usual manner. The cover contains the main and intermediate pressure plates, which are generously proportioned to aid heat dissipation. A single ball-thrust release mechanism provides for the operation of both clutches. The clutch adjacent to the flywheel controls the drive to the power take-off whereas the outer clutch operates the main drive through a hollow shaft through which the power take-off shaft passes. The two clutch driven plates are similar with the exception of the size of their splined hubs which respectively engage the solid power take-off and the hollow main drive shafts; they are of the rigid type and are fitted with heavy duty woven metallic friction facings.

In operation both the main drive and the power take-off clutches are engaged when the pedal is in the free position. When the pedal is depressed to an intermediate position the main drive clutch is disengaged but full torque continues to be transmitted to the power take-off; full depression of the pedal disengages both clutches, so allowing the engine to run free of load. It will thus be seen that the unit provides for the simultaneous operation of the main drive and the power take-off, of the power take-off only, or of neither of these.

Maintenance of the clutch in service throughout the long life of the friction facings is simple and straightforward, and is confined to two operations. The first is the proper maintenance of the free travel at the clutch pedal pad and this is controlled by an adjuster incorporated within the pedal linkage in the normal manner. The second concerns the maintenance of a specified clearance between three studs, mounted in the clutch cover and the outer or main pressure plate, which are readily accessible through the clutch housing.

The makers are Automotive Products Company Limited, Leamington Spa.

Fresh Water from the Sea

Life and industry depend upon fresh water. Most of the water in the world is salty and there is an increasing need for rectified supplies in many places. This article discusses the broad aspects of the subject and some of the successful methods which have been developed

By GEORGE W. McARD, A.M.I.Mech.E.

VERY few of those resident in civilized territories today realize the tremendous importance of water to the human race. When supplies are suspended for one reason or another, its value rises, but the knowledge that the flow will soon be resumed tempers any anxiety otherwise felt, and complacency assumes the reins. But to those living overseas, in tropical zones particularly, restricted water supplies can become a real problem, often aggravated the more by the sight of a vast ocean which normally cannot be tapped. With human thirst allied to industrial needs, however, men have at last begun to explore every available method of solving the problem, and concrete evidence is already to hand that a positive solution has been reached whereby water in considerable volume and purity is the outcome.

Yet curiously enough, the conversion of sea water to a state fit for human consumption is no longer the sole problem. Even in this country where total supplies of fresh water are ample for all our requirements, it has frequently to be conveyed through abnormally large and lengthy pipe lines to the area in need, thus

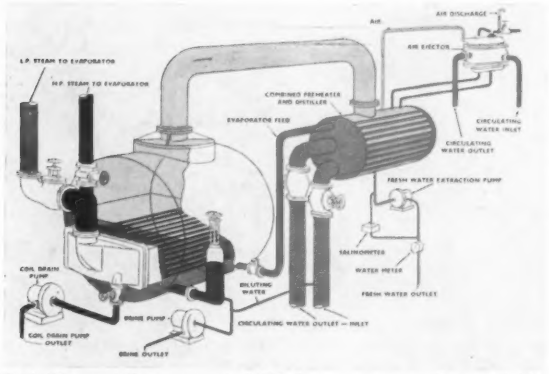


Fig. 1. Diagrammatic arrangement of Weir low-pressure evaporating and distilling plant

adding appreciably to the cost of supply. Similar conditions also prevail overseas in many parts, even in the U.S.A., where water must be piped for long distances from source to consumer for some of the larger industrial centres, and the correct solution is eventually found from a comparison of costs—transport of available fresh water or local purification of sea water.

The human demand in a large community will, of course, be a compound of the average consumption per head times the number of citizens to be catered for. Where industrial needs must be met, also irrigation schemes if such exist, allowance for these will be included, though generally speaking it is safe to assume that industry *or* irrigation, though seldom both, will be the rule. A figure of 20 gal per day per head of the

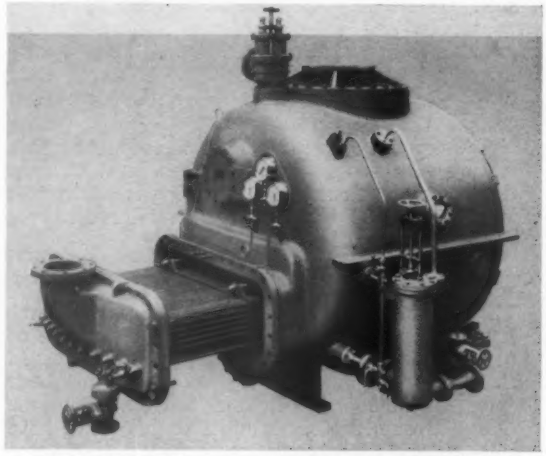


Fig. 2. Horizontal low-pressure evaporator with exposed element

population has come to be regarded as a reasonable standard to be taken for British urban areas, with double this quantity in the U.S.A., plus 25% extra coverage where large industrial users are to be included.

It will be appreciated how rapidly the demand can rise if consideration be given to the many aspects of modern life—hospitals and sanatoria, fire services, street cleansing and so forth—and the extent to which our present-day acceptance of water on tap would lead to a large degree of waste, were it not for an incessant watchfulness on the part of those responsible for safeguarding supplies. Indeed, from the figures already quoted above, assuming an area with a population of 10,000,000 to be catered for, a daily demand of 250 million gallons is at once apparent, or 500 M gal for a similar zone with U.S.A. standards.

A further factor which greatly concerns the subject under review has reference to the standard of purity which must be maintained. The natural requirements might seem, at first, to involve a 100% standard, but investigation will show that this is by no means the case. According to expert evidence some of the most acceptable drinking waters are known to possess a small admixture of sewage, and the writer has often felt that an analysis of some of our so-called medicinal waters might prove, at least, interesting. As, however, these notes are related to sea water alone, a summary of an analysis of an average sample is more appropriate here with some assessment following on the level of purity which is considered acceptable in any scheme of conversion to fresh water.

Sea water taken from areas unlikely to be seriously contaminated by local influences—sewage inlets, river

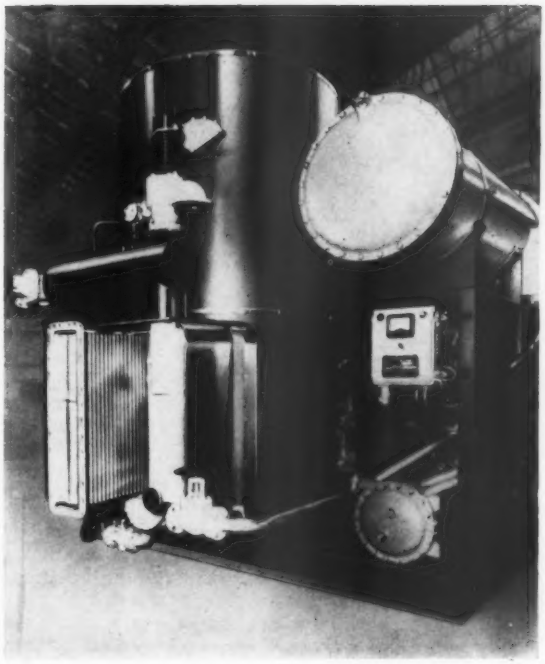


Fig. 3. Vertical sea water evaporator with Weir Thermoflex heating element, mounted on a single bedplate with distilling condenser and preheater

inflow and other local factors, good, bad and indifferent —is usually found to be a compound of various soluble salts, chiefly sodium chloride, that have been washed out of the earth by the action of rain and conveyed to the sea by ingathering streams and rivers. Actually the contents of sea water are found to be remarkably uniform where test samples are taken from mid-ocean, and their analysis shows the components, in parts per 1000, to be approximately as follows:

Sodium chloride	26·4
Magnesium chloride ...	3·15
Magnesium sulphate ...	2·07
Calcium sulphate	1·33
Potassium chloride	0·75
Magnesium bromide ...	0·07

with smaller quantities of nitrates, ammonia, and iron, the specific gravity of the combined solution at 15° C being 1·0248. The sample as analysed above was taken from the Irish Sea, and is regarded as a typical or good average for most areas, with differences in total weight of the dissolved solids amounting to as much as 10 parts in 1000 when compared with other samples taken from the North Sea, Atlantic and Pacific Oceans, also the Mediterranean. In areas like the Baltic and Black Seas, which to a large extent are enclosed and, therefore, more subject to the influence of rivers and streams from surrounding territories, the contents may be as low as half that found in the North Sea, while salts in the water of the Dead Sea are many times those tabled above.

From the analysis already given it will be noted that, in a bulk of sea water weighing 1000 lb there exists in solution no less than 33·77 lb of salts plus the unaccounted items (nitrates, ammonia, etc.) or virtually 34 lb, leaving a residue of pure water, after theoretically complete distillation, amounting to 966 lb. If we

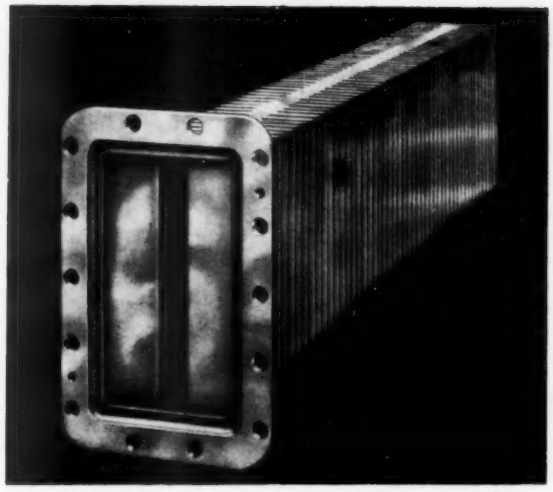


Fig. 4. Thermoflex evaporator heating element

assume the two limits as (a) that stated above for one extreme of impurity, and (b) 100% purification as an opposite possible, the most desirable condition would seem to lie somewhere between, with the resulting water ideal for drinking purposes, and, generally speaking, satisfactory for industrial and/or irrigation schemes.

As a matter of fact complete distillation, even for drinking purposes, is not in the interests of the community, since the product tends to become too insipid and flat, unless suitably aerated after purification and correctly adjusted for alkalinity. In the U.S.A. drinking water standards call for a water containing not more than 0·5 solids (in solution) per 1000 with a ceiling of 1·0 where the lower value may not be possible. The higher figure would therefore demand a removal of 33 lb of foreign content from every 1000 lb of sea water, and this fact will have to be catered for in the equipment provided.

Two lines of approach have been taken in resolving the problem of sea water conversion, the first being the needs of the individuals who are cast away in lifeboat or dinghy, the second being the large community for whom ways and means must be found of converting the neighbouring ocean. The first has been solved by the provision of a small compact unit which combines the correct chemical charges, a flexible filter bag and a transparent box into which the treated water is passed ready for drinking. The resulting product, thanks to the researches of many workers over the past quarter of a century, particularly in the Department of Scientific and Industrial Research and the laboratories of the Permutit Company Limited, now gives those stranded in seaborne craft a greatly increased chance of survival than did the small supply of drinking water formerly provided.

When the second problem comes under review the question of cost comes at once to the front, as however low the rate for conversion, once the scheme is embarked upon for a delivery of, say, one million gallons daily year in year out, a considerable charge will have to be met by the authority responsible for that area, and the need for a careful assessment at the outset becomes apparent. A bill of total cost will

include many sub-heads such as capital cost of plant and buildings, power and other operating charges (chemical additives will be essential in some cases) including labour, maintenance and renewals of worn-out mechanisms and valves.

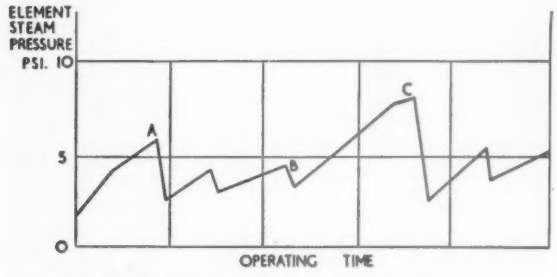


Fig. 5. Thermoflex element steam pressure plotted against operating time

The cost to the user of converted water in any area might be expected to influence the problem of waste, the actual cost being influenced to a large degree by the source of evaporation heat and the distance between conversion plant and customers' area. For the type of equipment at present possible in combination with electric power generating plant, the cost may be as low as a few pence per 1000 gal, but where the heat for evaporation requires independent equipment it may rise to 5s. per 1000 gal of fresh water—and be regarded in many areas as well worth it. An authority from Harwell, when speaking in Melbourne early this year, mentioned the possibility of distilling fresh water from sea water by atomic power at 5s. per million gallons, and of pumping sea water to the interior (of Australia) by the use of atomic power stations.

In this larger field a vast amount of research has been done, and many proposals which at first appeared to have good prospects were eventually demonstrated to be either too problematic or too costly in power to justify further research. The age-old laboratory experiment of precipitation has considerable attraction but this requires the addition of combining chemicals whose cost alone would be a prohibitive factor in big scale operation. Similarly, that more modern possibility of electrolysis would be too heavy in current consumption to justify large scale equipments, and the distillation process, judging by results, has hitherto yielded the most successful schemes.

Before proceeding to describe what has been achieved by distillation there is one further method, i.e., that by filtration, which deserves mention. In areas where the normal water supplies were unsuitable for drinking purposes good results were obtained by filtration through some medium such as ultra-fine sand, and it is on record that a very high degree of purification was reached in so far as micro-organisms were concerned; as high, indeed, as 97% being on record for the London area, where supplies were drawn at that time from the Thames, a highly polluted source. The salinity of that water was, in all probability, too minute a factor to influence adversely the filtered product, but a serious defect in this method lies in the necessity for frequent replacement of the sand from a fresh and unpolluted source, thus adding an appreciable extra to the cost of processing.

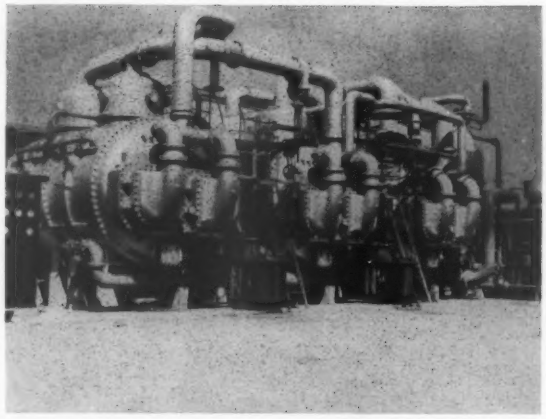


Fig. 6. One of three triple-effect sea water evaporating and distilling plants at the British Petroleum Refinery at Aden. The total output of fresh water from these plants is 462,000 gal a day for boiler feeding

The mention of distillation brings to mind experiments in the use of solar heat, at first glance a most natural source of power, and one which, in itself, might suggest a low cost outlay. The sun's rays alone, however, even in the hottest zones such as North Africa, the Persian Gulf and similar areas where they are capable of so much human discomfort, are nevertheless officially classified among the sources of "low temperature" heat apart from the inclusion of a scheme, combining mirrors and lenses, which has been used experimentally at considerably increased cost to intensify the heat application in a localized area. Such a scheme as that envisaged obviously runs up the cost of purified water supplies rapidly, adding also to the labour cost due to the necessity for maintaining the layout in a high state of efficiency. Further problems would be added by the proximity of heavy sand-storms in the operating area, which impose still heavier demands on the maintenance squads, and the general opinion among engineers who are experienced in this subject is definitely adverse to this scheme.

The solution today undoubtedly appears to be on the lines of evaporating and distilling equipment. Persistent research into the true chemical constitution of sea water has revealed the manner in which the various elements can be broken up and disposed of, also the effect of varying degrees of temperature on the serious ancillary problem of scale formation. The ultra-heavy content of sodium chloride in sea water, rendering it the chief enemy from the viewpoint of drinking water, and the tendency to scale formation due to the remaining constituents, have led the designer to balance carefully the relative temperatures on both sides of the evaporating unit. This permits an automatic check to be maintained on the purity of the fresh water output and the constant removal of brine and sludge to ensure uniform density at all times, of brine in the evaporator, with a minimum amount of scaling over long periods of operation. The aim of the designer today is naturally to extend the periods between de-scaling operations as much as possible, and a figure of three years service at full duty of approximately a million gallons daily has already been achieved.

The diagram in Fig. 1 illustrates the general layout of the plant involved and the flow of steam, sea water and vapour, Fig. 2 showing an evaporating unit with

its heating element withdrawn for examination. A complete evaporating and distilling equipment, designed for high pressure service, is shown in Fig. 3 with its heating element partly withdrawn, an isolated view of the latter being seen in Fig. 4. This unit is made of non-ferrous material with corrugated or fluted sides specially designed to expose the maximum heating surface, at the same time rendering it capable of flexing under variation of steam pressure and causing the scale, which otherwise tends to build up on the element, to flake off into the base of the shell whenever pressure in the unit rises to a peak, as seen, for example, at A, B and C in Fig. 5. When the evaporator is shut down the scale, which is smooth and brittle in character, can be easily raked out.

The process of evaporation only suffices to dispose of the scale-forming solids, and the resulting distillate must be de-aerated before delivery to the boiler in order to remove oxygen and other gases which may be dissolved—gases which have been proved to be the cause of much corrosion and pitting in boiler surfaces and tubes. Treatment for alkalinity follows de-aeration according to local requirements. For high-pressure installations requiring continuous operation without shutting down for scale removal a chemical equipment is used which prevents scale formation on the heating element and evaporator surfaces. This ensures maximum heat transfer rate with continuous operation maintaining the full specified output of fresh water.

The fresh water provided in the manner described above can be regarded as virtually a by-product of a large power generating station's daily operation since the heat in the exhaust steam from the turbines can be used very effectively in the sea water evaporating plant. A modern example is seen in Fig. 6.

Recent developments indicate that future research will find unlimited and undreamed-of wealth in the oceans which already have proved so marvellous a medium in the sphere of transport. Already unparalleled levels in temperature and electrical energy have been reached, and it is by no means an unreasonable stretch of imagination to suggest that vast reserves of power may yet be drawn from the sea.

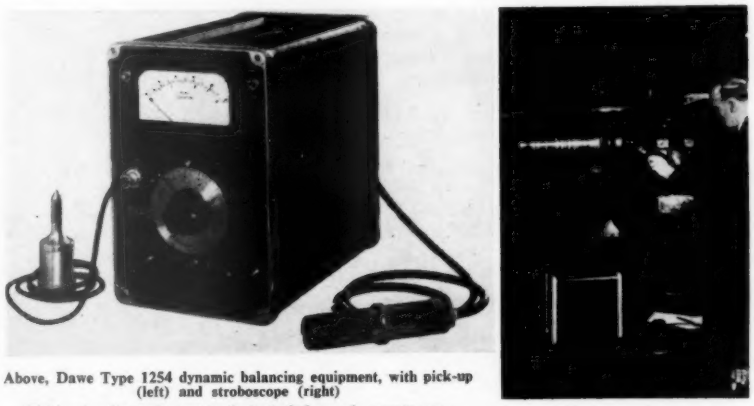
Acknowledgment is made to G. & J. Weir Limited, Cathcart, Glasgow, for illustrations of their evaporating equipment.

Dynamic Balancing on site

The provision of portable balancing equipment where the quantities involved are insufficient to justify the setting up of a dynamic balancing machine has been made by Dawe Instruments Limited, 99 Uxbridge Road, London W5, who now offer their Dawe Type 1254 portable balancing equipment. It comprises the sensing and measuring circuits of a conventional balancing machine, but balances components in their own bearing and using their own drive.

To use the Type 1254 the operator merely applies the vibration pick-up to the machine bearing and reads the vibration arising from the unbalance off the meter. A stroboscopic lamp, triggered from the pick-up, "freezes" the rotor so that a positional reading can also be taken. A known mass is then mounted on the rotor and a second set of readings taken. By plotting the two sets of readings on a polar diagram, the correction required to eliminate the unbalance is shown at a glance.

To balance a more complex machine with a number of components rotating at different speeds, the overall vibration level can first be measured as described, the stroboscope giving a stationary image of the unbalanced part producing the maximum amount of vibration. To determine how much each part contributes to the overall vibration level, a filter is switched into circuit and the amplifier tuned in turn to each of the various component frequencies making up the total vibration. The meter then indicates the vibration due to unbalance in the component associated with the selected frequency. The component concerned can be seen at a glance, since it alone appears stationary.



Above, Dawe Type 1254 dynamic balancing equipment, with pick-up (left) and stroboscope (right)

Right, using the equipment to check the balance of converter sets

The Type 1254 Equipment can also be applied either as a vibration meter or as a stroboscope. In the latter case, the calibrated frequency control of the filter enables the stroboscope to be used to measure the speeds of rotational and cyclical mechanisms without the need for any mechanical contact.

Agricultural Engineers at Brussels

The exhibit of the British Agricultural Engineering Industry at the Brussels Exhibition is the first occasion on which the members of the industry have banded together and presented a comprehensive picture of their products and the areas they serve. The exhibit consists of specially drawn maps showing for the first time a comprehensive view of the more important of the world's crops and agricultural products together with the British tractor and equipment distribution in each area.

To give an impression of the enormous range of British agricultural machinery the maps are surrounded by 140 coloured photographs of the machinery in operation under widely differing conditions. Although all of them cannot be shown, these conditions range from Antarctica to tea gardens set high on equatorial mountains, from flooded paddy fields to conditions of semi-desert and from lush English meadows to Brazilian jungles.

Hot Blast for Small Foundry Cupolas

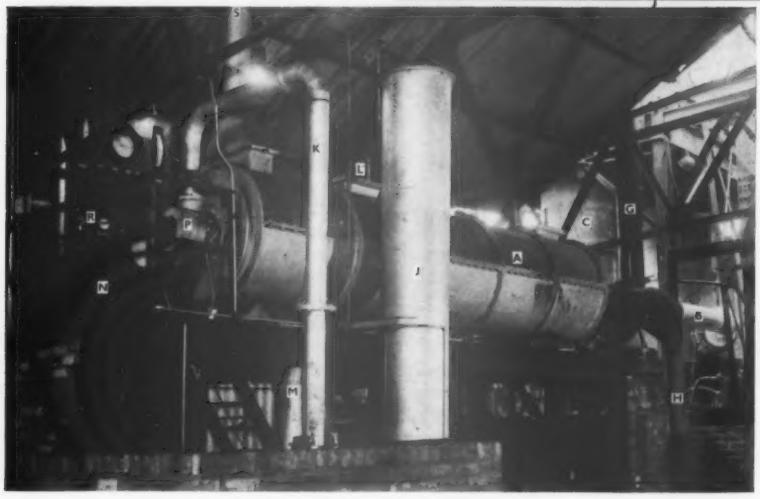
The introduction of an independently oil-fired hot blast installation at an iron foundry in the Midlands has resulted in substantial savings in coke, ferro-silicon and manganese and a greatly increased melting rate; economies which rapidly offset the cost of installation and use of oil fuel

IN a highly competitive branch of engineering such as general iron founding it is essential to effect every economy and method in order to produce quality castings at a attractive price. One method which will show considerable economies in melting costs is the preheating of the blast up to temperatures of 500° C. The advantages of hot blast cupola operation can be summarized as follows: reduced coke consumption with an attendant reduction in sulphur impurities, reduced pig iron consumption and oxidation losses and increases in metal temperature, melting rate and carbon pick-up.

Pre-heat of the blast is usually achieved by one of two methods—either by the installation of a recuperative system, in which the cupola gases are withdrawn from the stack below the charging sill, burned in a combustion chamber and passed through a recuperator, or by the installation of an independently-fired heat exchanger.

The main disadvantages of the recuperative or top gas system for the small foundry are the high capital and maintenance cost of the equipment, the difficulty of successfully converting existing cupolas due to the considerable space taken up by the gas off-takes, dust catchers, combustion chamber and recuperator and the time taken to obtain a consistent hot blast, due to fluctuations in melting rate and tapping procedure. Again inefficient blast may result where the lack of height above the tuyeres to the charging sill prevent the correct location of the gas off-takes.

The second method, that of using an independently oil-fired heat exchanger has many points in its favour. Probably the first and most important are its low capital cost and speed with which the blast temperature can be reached; it is possible to reach a blast temperature of 500° C within 30 min from cold. Other features are absence of dust accumulation within the heat exchanger, its independence of cupola operating conditions and the compactness of the plant and suitability for installation on existing cupolas without drastic alterations.



Above, the Incandescent hot blast installation at Brockmoor Foundry. The oil fired heater capable of raising 2000 cu ft of cold air per min to a temperature of 500°C is connected to a pair of 4 ton/hr cupolas. Left, the heat exchanger mounted on a staging above the blowers

A, heat exchanger. B, blast main. C, and D, cupolas. E, hot gas isolating valve. F, windbelt. G, by-pass vent pipe. H, cold blast pipe. J, process air intake. K, burner air supply. L, explosion doors. M, process air supply. N, control panel. P, swirl type burner. R, oil supply pipe. S, waste gas exhaust

The Incandescent hot blast system developed by The Incandescent Heat Company Limited, Foundry Plant Division, Cornwall Road, Smethwick, Birmingham, is of the latter type and consists essentially of a high efficiency recirculating oil-fired heat exchanger, incorporating a specially designed combustion chamber to ensure maximum heat release from

the fuel through a pressure jet burner. Automatic spark ignition and electronic flame failure devices are fitted, together with automatic temperature control equipment.

The first adaptation of this system made at The Brockmoor Foundry Company Limited, Brockmoor, Brierley Hill, Staffs, has been working successfully for twelve months and is enabling a 25% saving to be made in coke alone. This company who are manufacturers of black heart malleable and high duty grey iron castings operate two cupolas alternately to feed a 4 ton receiver. Each is capable of a full blast rate of 4½ ton/hr, though the normal working rate is 4 ton of blackheart malleable iron per hr, the total charge weighing some 11 cwt made up of 6 cwt malleable scrap and 5 cwt steel. The cupolas measure 4 ft outside dia, and with 6 in. brick lining provide an approximate internal diameter of 2 ft 9 in. for the charge. The windbelts are arranged in four segments external to the cupola shell to allow for lagging and the provision of water cooling of the shell. The cooling system is simple, a water curtain issuing from holes in a copper pipe ring surrounding the shell, falls to a gutter fixed above the level of the tuyeres and is recirculated to a storage tank in the roof. The new blast main measuring 18 in. bore at the heat exchanger and reducing to a 15 in. bore Y-junction pipe feeds two 12 in. bore branch pipes, each of which terminates in a Westwood & Wrights hot gas valve for isolating the cupolas during relining and maintenance. A vent pipe to the roof, normally closed by a steel flap is sited at the junction pipe to permit discharge of the hot blast to atmosphere when melting is interrupted for short periods and the cold blast pipe connexion and blower have been retained for emergency running.

The heat exchanger is extremely compact, this particular model measuring 4 ft dia × 18 ft long is mounted on a steel staging together with the control panel. The high pressure swirl type burner using diesel oil, was specially developed to allow a high heat release in the very limited combustion space available. The combustion chamber itself is approximately 18 in. dia × 3 ft long and is ram lined with a special refractory approximately 2 in. thick, the only lining required in the whole heater. The end of the combustion chamber fires into a centrifugally cast chrome/iron centre tube about 14 in. dia and 18 ft long and the hot gases are recirculated by means of a venturi action along the outside of a bundle of alloy iron tubes, approximately five recirculations of the hot gases being obtained before the waste gases go to atmosphere. The process air first scrubs the side of the combustion chamber before passing through the bundle of tubes and into the hot blast main. The heat exchanger casing is insulated with insulation bricks protected by chrome/iron sheets. The oil pressure at the burner is between 150 and 200 psi and the thermal efficiency of the equipment is between 80 and 84% and provides hot blast at the following rates: 2500 cfm at 350° C, 2000 cfm at 450° C and 1750 cfm at 500° C, the drop in rate being due to the expansion of the air. Oil consumption is approximately 10 gph. Instrumentation on the control panel includes a temperature gauge, process air flow recorder (air blast rate), combustion air flow gauge, oil pressure gauge and an oil meter.

Skilled supervision of the equipment is not required as various protection devices are fitted, consisting of a blast temperature controller, which reduces the oil pressure should the blast temperature rise above a certain value. When the blast temperature is reduced the oil pressure returns to its normal figure. The oil supply to the burner is automatically cut off should the combustion air to the burner fail or the process air from the cupola blowing fan fail. There is a photo-electric cell sited on the flame which shuts off the oil supply should the flame be extinguished and also an overriding thermostat, which shuts down the equipment completely if the hot blast temperature rises above a certain figure. Automatic lighting is by spark ignition and, if the burner should not light at the first attempt, timing devices give a time lapse before re-lighting.

To give an indication of the fuel and ferrous-silicon-manganese saving achieved the following figures were obtained when melting 4 ton of blackheart malleable iron per hr, 9–10 hr per day. 5 days per week.

Cold Blast	**Hot Blast**
6 cwt malleable scrap	6 cwt malleable scrap
5 cwt steel	5 cwt steel
14 lb Ferro Silicon	5 lb Ferro Silicon
7 lb Ferro Manganese	3 lb Ferro Manganese
2 cwt coke =5.5:1	1½ cwt coke =7.3:1
44 to 48 charges per day	50 to 58 charges per day

Savings per month of:

	£
Coke 25 ton at £12 4s 0d ton	=305
Ferro Silicon 4 ton at £75 0s 0d ton	=300
Ferro Manganese 1¾ ton at £85 0s 0d ton	=148
Total savings per month	=753
Less cost of diesel oil	=120
Nett saving of approximately	£633 *per month.*

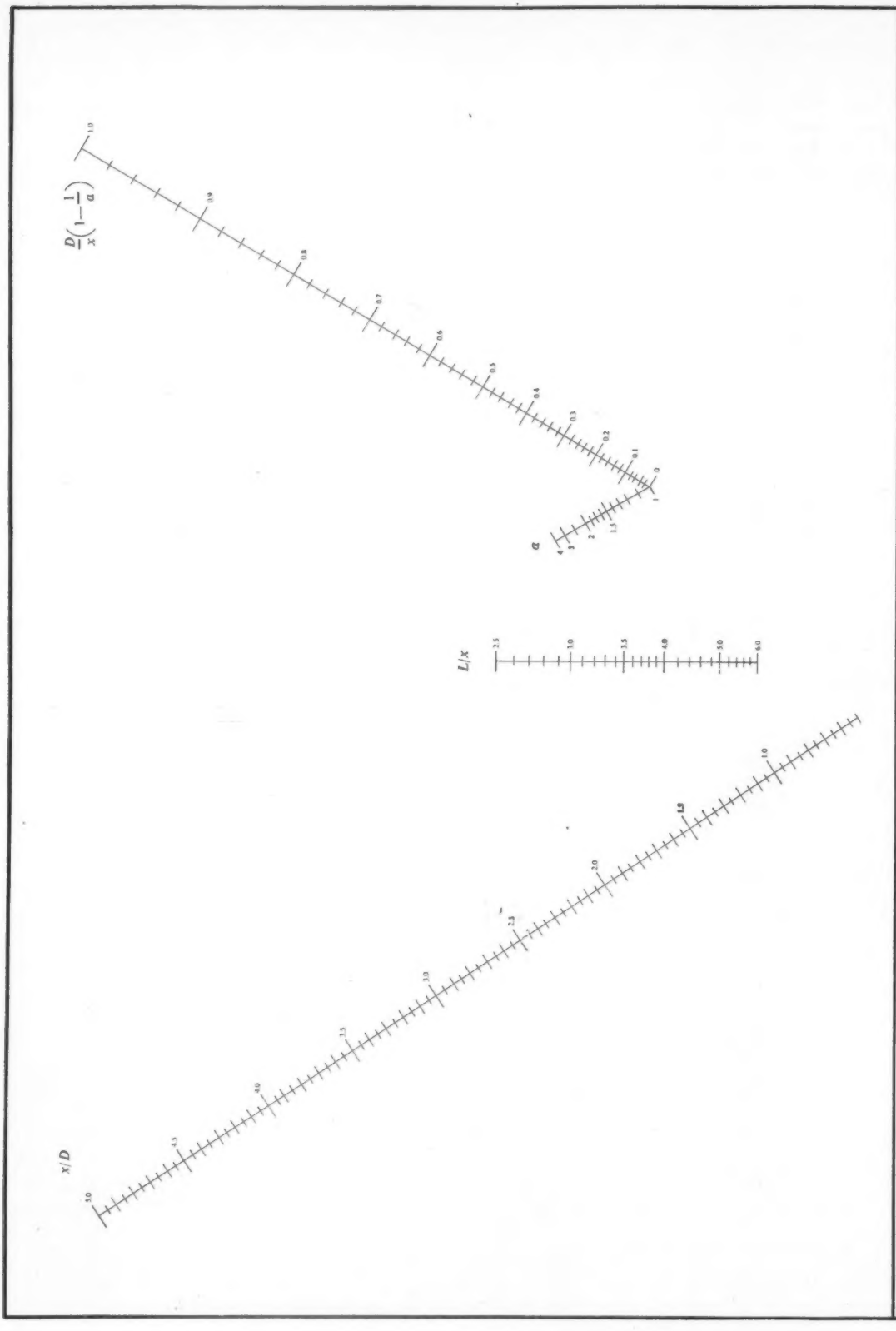
The approximate cost of this installation was £5000. The makers state that other blast systems are in hand suitable for cupolas of up to 8 ton per hr capacity.

Fuel Flow Test House

The new fuel flow test house, the most extensive of its kind in Europe, which was opened in June by the Minister of Supply, the Rt. Hon. Aubrey Jones, M.P., has been set up by Firth Cleveland Instruments Limited, the recently formed subsidiary of Simmonds Aerocessories Limited, at Treforest, Cardiff, Glamorgan, South Wales.

The test house provides facilities for calibrating and production-testing flowmeters, water separators, valves and other fluid handling equipment. It includes modern apparatus for future development requirements, and complete facilities are available to test to Government and other official specifications. These facilities are available to all manufacturers of equipment concerned with liquid fuel products, both in the United Kingdom and in Western Europe.

The two companies provide equipment for handling fluids, including instruments for quality and quantity measurement, filters to remove water and dirt from liquid products, remotely-operated valves for pipelines to control or shut-off flow, various types of indicators for remote read-out purposes, with signals to operate print-out equipment, or for telemetering purposes. Much of their equipment is used in aircraft and warships.


$\frac{D}{x}\left(1-\frac{1}{a}\right)$
1.0
0.9
0.8
0.7
0.6
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0.4
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a
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NOMOGRAM FOR BELT DRIVES

By C. N. Davies, M.Sc., D.Sc., F.Inst.P.

"MECHANICAL WORLD"

DATA-SHEET—No. 7

The fundamental formula for belt drives derived from geometrical considerations is:

$$L/x=(\pi D/x)-2\left\{(D/2x)(1-1/a)\arccos[(D/2x)(1-1/a)]-\sqrt{1-[(D/2x)(1-1/a)]^2}\right\} \quad (1)$$

where L = length of belt.

x = distance between pulley centres.

D = diameter of large pulley.

d = diameter of small pulley.

a = D/d = speed ratio.

With the aid of the nomogram practically any belt problem can be solved with accuracy enough for most purposes. Should a very high standard of accuracy be required, the nomogram can be used to obtain a first approximation which is then improved by the following formula which was deduced by differentiating equation (1):

$$\frac{\triangle L}{\triangle D}=\pi-(1-1/a)\left\{\arccos[(D/2x)(1-1/a)]-\frac{(D/x)(1-1/a)}{\sqrt{1-[(D/2x)(1-1/a)]^2}}\right\} \quad (2)$$

The value of D given by the nomogram is inserted in equation (1) which is solved for L; the resulting value of L will be slightly in error. This error, $\triangle L$, is then put in equation (2) which is solved for $\triangle D$, the correction to be applied to the erroneous value of D originally obtained from the nomogram. If necessary the process is then repeated until the error in D is negligible.

The nomogram is in terms of the ratios of L and D to x, the distance between the shaft centres, so that it is immaterial what unit of length is employed.

If the speed ratio and the size of the large pulley are known it is best to work out $\frac{D}{x}\left(1-\frac{1}{a}\right)$ and stretch a thread from the right hand scale to the left, reading the value of L/x from where it cuts the centre scale. Should D be unknown, however, the short scale of a is employed in conjunction with the centre scale of L/x to obtain D/x.

Example: A belt drive is required to give ratios of 3:1 and 2.5:1, between shafts on 6 in. centres, with the large pulley 3 in. dia. and the belt length the same for each speed.

For $a = 3$, $\frac{D}{x}\left(1-\frac{1}{a}\right)=\frac{1}{3}$, and $x/D = 2$.

The nomogram gives $L/x = 3.08$ or $L = 18.48$ in.

When $a = 2.5$, with the above value of L/x, the nomogram gives $x/D = 2.1$ so that $D = 2.86$ in.

Direct calculation by equation (1) makes $L = 18.45$ in. for $a = 3$. Putting the nomogram value, $D = 2.86$, and $a = 2.5$ in equation (1) makes $L = 18.41$, hence the error in L is 0.04 in. From equation (2) $\triangle L/\triangle D = 2.574$ so that the error in D is $0.04/2.574 = 0.015$. The corrected value of D is thus $2.86+0.015 = 2.875$. Feeding this value back into equation (1) again gives the same value of L so further correction is not necessary.

technique

devoted to the discussion of practical problems. Readers are invited to contribute items from their own experience in matters relating to design, manufacture and maintenance. Payment will be made for published contributions.

Any Questions ? We welcome inquiries concerning difficulties arising out of our readers' general work, for treatment in the **technique** section. The full name and address of the writer (not necessarily for publication) must accompany each communication

Sampling Dust and Fume

A sampling apparatus has been designed by the British Iron and Steel Research Association for measuring industrial dust, such as the red-oxide fume emitted with hot waste gas from steelmaking processes, and the fine or coarse dust arising from crushing, grinding, sieving or other processes, and from sinter plants.

The arrangement of the complete apparatus or sampling trains is shown in Fig. 1. A stainless steel probe, carrying a sharp-edged nozzle, faces directly into the stream of dusty gas and a sample is withdrawn isokinetically, i.e. it flows into the nozzle in the same direction and at the same velocity as the local undistributed gas streams. This ensures that the dust content of the sample accurately represents that of the main gas stream at that point. The gas sample is then drawn through the weighed filter and cooled below air temperature in the two coils to ensure that corrosive liquids are not condensed in the remainder of the sampling train. Two gas-tight vane pumps, arranged in parallel, then expel the filtered and cooled gas sample through an integrating gas meter and a gas flow-rate indicator. The mass of dust and fume in the gas sample is determined by re-weighing the filter, and the concentration is obtained by dividing this mass by the volume of the gas sample.

In order to calculate the correct isokinetic sampling rate, it is necessary to measure the velocity and temperature of the gases in the stack. This is done by placing a pitot tube and a sheathed thermocouple near the sampling nozzle, but not obstructing it. Simple tables can be used to obtain the required sampling rate from the pitot-tube reading.

The particular arrangement of the sampling train shown in Fig. 1 with two vane pumps connected in parallel has proved very convenient in use. Two small pumps are preferable to one larger one since they allow a wider range of sampling rates and easier control, as well as being easier to transport. Placing the meter after the pumps ensures that the sample is metered at substantially constant temperature and pressure. This simplifies the calculation of dust and fume concentrations in terms of standard gas volumes and makes it possible to use the simple form of sampling flow-rate control described above. The inclusion in the sampling train of an integrating gas meter avoids determining the volume of the gas sample by integrating a flow-rate/time diagram—a tedious and sometimes inaccurate procedure.

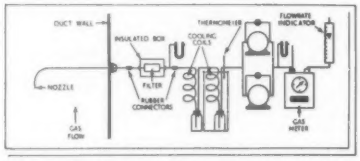


Fig. 1.—Sampling train for measurements on open-hearth waste gases

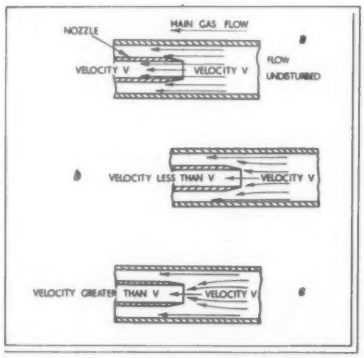


Fig. 2.—Effect of incorrect sampling velocity on composition of sample. (a) Isokinetic sampling: true concentration obtained, particle size representative. (b) Sampling rate less than isokinetic: higher than true concentration obtained, excessive number of coarse particles in the sample. (c) Sampling rate greater than isokinetic : lower than true concentration obtained, deficiency of coarse particles in the sample

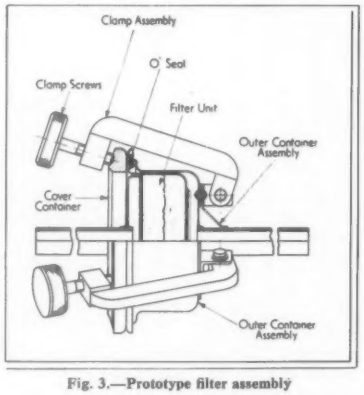


Fig. 3.—Prototype filter assembly

Rates of gas and fume emission from steelmaking processes can vary rapidly with time. To be of use the sampling train must collect a weighable sample of dust and fume in a short period—often less than five minutes—and be ready to take another within a minute. To meet these requirements the original hand-built apparatus used by the Physics Department of BISRA has been re-designed in collaboration with the Longworth Scientific Instrument Company Limited, Thames Street, Abingdon, Berks. A robust filter assembly is being constructed which incorporates a throw-away filter of graded glass fibres, held in a re-usable stainless steel canister, the whole of which can be weighed on a chemical balance. This assembly will filter iron-oxide fume from corrosive gases at 300° C at a rate of 3 cu ft per min.

Boiler Shop Reorganization

The boiler shop at Crewe Locomotive Works covers the plating and welding sections which are concerned with the preparation and fabrication of sub-assemblies for locomotive construction and the welding of fabricated components generally. Recent reorganization has been towards a progressive flow of work, the improvement of working conditions and prevention of accidents, the provision of improved accommodation for tools and small stores, and improved facilities for handling and storage of gas cylinders.

Fig. 1.—General view of shop showing floor markers, flow-line arrangement of work stations and "goggles" safety reminder on overhead crane

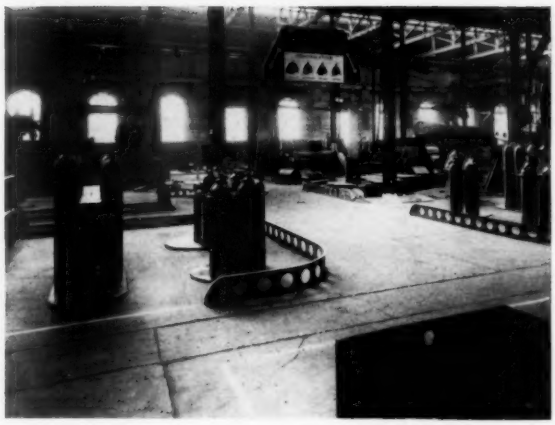


Fig. 2.—At the new gas cylinder station every care has been taken to render cylinders positively identifiable and readily accessible

The gangways of the shop have been clearly defined by means of white lines painted on the floor in judicious combination with fabricated steel markers. This ensures that clear passage is maintained for both pedestrian and motor traffic and facilitates movements about the shop. The fabricated markers are simple structures manufactured in welded steel plate and suitably painted, and Fig. 1 shows these together with a view of a typical gangway.

A unit-type of welding compound has been adopted which whilst achieving a robust construction and permanent appearance can be dismantled and re-erected without difficulty should re-siting be necessary at any time. The components, tubular stanchions and sheet-metal walls, are bolted together, and an interesting feature of this form of construction is that the components can equally well be used for the erection of draught screens or other general partitions. The internal surfaces of the compounds are painted in a matt finish in order to obtain a low degree of light reflection and so minimize the effect of the glare of the welding arc. Provision is made inside each compound for the display of working drawings so that these can be consulted readily during fabrication. The drawing is held at a convenient height by means of spring clips attached to one of the wall panels.

The flow of work has been arranged on progressive lines, and a typical example is illustrated in Fig. 1 which shows the layout for the production of fabricated sub-assemblies for diesel-electric shunting locomotives. All assembly fixtures and similar special equpiment have been painted in maroon in order to make them readily distinguishable, and each station is further identified by a name-board which is attached to an adjacent crane stanchion and which indicates the particular component being dealt with in that area.

In view of the increase in the variety of gases used in production processes, special attention has been paid to the identification, storage and handling of gas cylinders with a view to obtaining the best form of handling and control with a maximum degree of safety, and a gas-cylinder station has been set up in a convenient position in the shop. As can be seen in Fig. 2, the station is divided into two sections embracing full and empty cylinders respectively, and each section is further divided between fuel and non-fuel gases. Suspended in a central position over the station is a large notice board which portrays the three major precautions which are necessary in the handling of gas cylinders, and an indentification panel showing the standard colour-code which is used to identify the content of cylinders.

The design of the stands for the accommodation of both full and empty cylinders provides for secure holding of the cylinders in the vertical position in such a manner that they are readily identifiable and have their taps in the most accessible position. To prevent their receiving shocks during unloading and handling operations special damping mats have been provided.

At ten strategic points throughout the shop a long handled gas cylinder key has been provided and clearly labelled. Thus, in the event of any emergency involving the necessity to close a gas cylinder cock from a distance greater than that afforded by the normal gas cylinder key, a suitable tool is available and readily visible.

Each permanent working position in the shop is provided with its own stand for cylinders, thus avoiding the risk of cylinders being accidentally knocked over. For temporary working positions and for the general transport of cylinders around the shop, special trucks fitted with shock absorbing springs have been provided, and these enable the cylinders to be located safely in the upright position without being subject to shock or to the risk of being knocked over.

In order to economize in floor space whilst providing adequate storage for individual workmen's tools, etc., four-compartment tool boxes have been provided to replace the single boxes previously used. General user tools and small consumable stores are now dispensed from a central store, which also embraces a reclamation depot in which nuts, bolts, etc., are reconditioned and made available for further use.

Opportunity has been taken to instal a first-aid station, and this has proved of considerable value in the prompt treatment of minor injuries. Emphasis has, however, been placed wherever possible upon the need for accident prevention, and "goggles" signs have been mounted on the overhead cranes in the manner

visible in Fig. 1 to serve as a constant reminder of the need for goggles wherever eyesight is endangered. The fact that the cranes are constantly moving up and down the shop results in these signs being seen in ever-varying positions, and it is felt that this impresses their purpose more frequently in the minds of the observers than would fixed signs.

Due regard has been paid to the joint consultation procedure in effecting this reorganization, and the improvements outlined in this article have been carried out with the full co-operation of the staff concerned.

Handling Work for Galvanizing

New building and construction developments, such as the gaining popularity of curtain walling employing zinc and aluminium coated steel sheets for exterior cladding of many types of buildings, are providing the metal window industry with a substantial new outlet for its products. The size of the industry is reflected by the average monthly production figure of 6484 tons of metal windows produced during 1957, some 20% of this total being exported.

Integration of the new product into current production processes presents few problems, especially where galvanizing is concerned. Three methods are currently employed; namely, hot dip, zinc spray and electro-galvanizing. The hot dip process accounts for the treatment of a major portion of the output and although designed to handle large tonnages per shift, is sufficiently flexible to accommodate a variety of products other than metal windows without alteration to plant.

At the Crittall Manufacturing Company's Braintree Works, the hot dip process is served by a monorail system, which is part of a works system. Small trolleys or carriers, from which hooks are suspended are hand-hauled short distances along this system, loading being by lowering short sections of the rail, complete with carrier and suspended hooks. Consolidated Pneumatic 6 in. dia rams are used in the main shop for raising and lowering these sections whilst a number of 4 in. units are installed in the paint department. The rams operate in a highly corrosive atmosphere, being subject to acidic fumes from the tanks and to accumulations of corrosive material which tends to form on top of the cylinders. They are regularly inspected and maintained, however, and have been found most suitable for the conditions.

The hot dip process consists of pickling, two washing stages, fluxing, drying, galvanizing, cooling and

One of the Consolidated Pneumatic vertical rams used for loading galvanized products to the monorail system prior to painting

etching stages. The first stage, pickling, is carried out in a dilute solution of hot sulphuric acid, the temperature being controlled to between 140 and 150° F. After mill scale and other impurities have been removed, washing follows to eliminate iron salts, the first wash in a hot tank being followed by a cold wash. To ensure complete washing, the tanks are provided with a constant intake of fresh water and a waste overflow.

When all iron salts have been completely removed, a flux of zinc ammonium chloride is applied at a temperature of 150° F. This is effected in a further bath and its object when dry is to ensure an even flow of zinc in the galvanizing stage and to facilitate its alloying with the steel.

After fluxing, the next stage consists of drying in a carefully controlled air temperature. The removal of moisture is essential to prevent spattering in the galvanizing stage and close temperature control is necessary to prevent breakdown of the flux by interaction with the steel, with consequent heavy dross formation in the spelter bath.

From pickling to drying, the stages are carried out by a fully automatic circuit. After drying, however, the trolleys carrying the products to be galvanized are hand hauled a short distance to the spelter bath, an arrangement which allows ample flexibility in the system.

A separate circuit controls the next group of stages. These commence with the galvanizing stage, carried out in a spelter bath kept at a temperature of 860° F. The surface is skimmed before immersion to remove zinc oxide and to prevent any possible contamination of the products, it is skimmed again before the windows or plates are withdrawn. A cooling stage follows and where frames or sheets are required to be painted they are treated by etching in a weak solution of phosphoric acid and zinc phosphate. This provides a roughened surface and a phosphate coating which has been found highly suitable for paint work.

Of prime importance in the process is a precise degree of control, whilst a measure of flexibility is necessary to deal with products other than standard.

The first of the two circuits is fully automatic, a timer being actuated by the fall of hoists controlling the vertical movement of the frames. When the timer makes contact, solenoid operated air valves supply air to the 4 in. dia rams responsible for horizontal movement, the whole operation being contained by a series of integrated circuits incorporating "latch in" and "latch out" stages.

Scaffolding for Boiler Overhaul

In order to provide safe and complete access to the interior of the water tube boilers at Marchwood Generating Station, near Southampton, successful use is being made of specially designed scaffolding constructed from Self-Lock frames supplied and erected by the Mills Scaffold Company Limited.

This new method was used experimentally six months ago, when it was found that owing to the ease of installation and erection of the Self-Lock equipment, boilers shut down for inspection could be recommissioned much more quickly than before. The frames, measuring 5 ft. × 2 ft have to be passed one at a time into the boiler through a man-hole

measuring 2 ft. × 1 ft 3 in. Despite this, it is possible for 13 men to erect or dismantle a complete scaffold in 13 hr as opposed to the three days normally required when using standard 2 in. dia. scaffold tube and fittings, the cost of the scaffold frames being absorbed by the saving achieved from the reduced shutdown period of one boiler.

The boiler in which this material was first employed was a John Thompson water tube unit of 550 Klb/hr output. Designed for coal firing, it had been modified for oil burning, the modifications including the closure of the ashpit by fitting a false floor of fire bricks carried on a framework of T-section girders. The scaffolding consisted of nine towers joined together with tie bars, the layout being shown in the sketch. The centre tower was carried directly on the false floor of the ashpit, the two banks of towers on either side being cantilevered off and rising to a height of 56 ft and 60 ft respectively, the variation being due to the sloping roof of the boiler. Upon erection, the clearance of the inside face of the boiler and the scaffolding was found to be approximately 6 in.

The base of the boiler showing the scaffolding cantilevered off from the central tower

and to ensure complete stability of the structure, lengths of 2 in. dia. scaffolding tube (known as ledgers) were attached to the towers, the ends of the tubing butting up against the boiler walls. In this way, the scaffolding was stabilized on all four sides.

Tapering the Ends of Screwdriver Blades

The tapering of several hundred screwdriver blades for a heavy engineering project meant that it was necessary to remove a considerable proportion of the material from one end of a round shaft, and as cheapness was an important factor because repeated use and severe abuse soon rendered them no longer fit for further tightening, it was essential that the operation be performed quickly. Because this process required a longer time than the initial operation of facing and parting off on a turret lathe, a saving in the loading time meant that costs were maintained at a low level, and if the work was carried out reasonably accurately a subsequent operation to grind the blanks would not be necessary.

Fig. 1 shows the finished screwdriver blade—a short length of $\frac{3}{4}$ in. steel rod with the usual tapered end to fit the screw, only on this occasion the taper was somewhat steeper than usual in an effort to increase the blade strength and so make chipping less frequent.

The large diameter overcame the necessity of providing a support against the cutting pressure—some consideration was given to this feature before embarking on the construction of this fixture as the broad cut made such a condition as chattering likely, but a fine feed, a higher spindle speed than is normally applied coupled with the fact the two sets of cutters were staggered half a tooth when placed on the milling machine mandrel, all assisted in damping out vibration and allowed

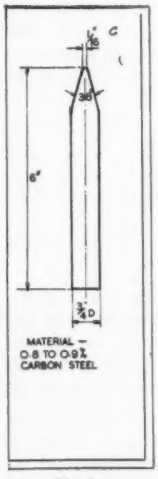


Fig. 1.

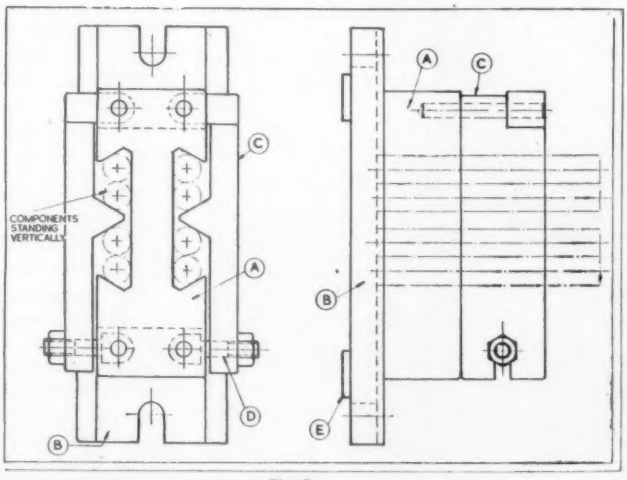


Fig. 2.

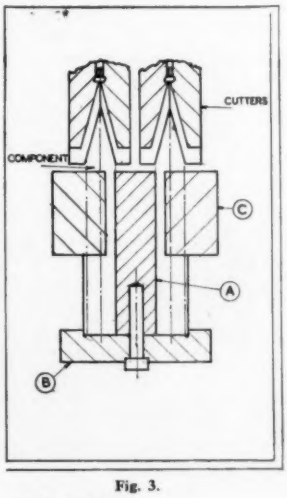


Fig. 3.

Figs. 1 to 3 (left to right)—Finished screwdriver blade, holder for shanks, and end view showing cutters in relation to shanks

the design to develop as shown at Fig. 2.

The location block A was tenoned into a base member B and each side of this location was angled to accommodate two blades. In an endeavour to assist loading the swinging clamps C were partially closed and this meant the spindles were inserted into the dovetails but still stood vertically and could not fall over. A final tightening caused the V on the clamps to push the blades into the corners and each locked the next member. While a single cam handle or nut would lock both clamps simultaneously, separate loading of each side was considered slightly easier and as a nut is a more secure method of tightening when milling instead of a cam handle, these were adopted as illustrated on the drawing.

The cross sectional drawing shows that close support was given to the blades by arranging as near to the cutters as possible.

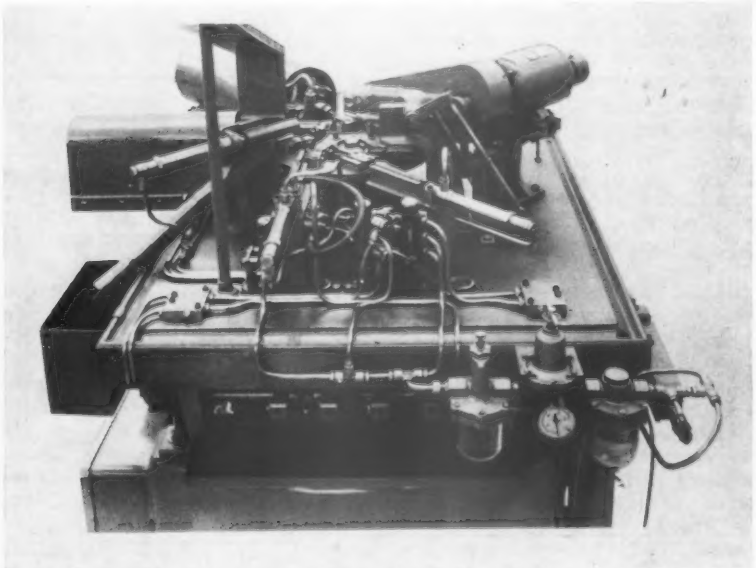
MODIFIED BRACKET FOR COAL CUTTERS—This single wheel haulage bracket to replace the conventional double-wheel bracket on coal cutting machines used in waffling has been designed by Mr. H. Shooter, assistant unit mechanical engineer at Brookhill colliery, with the object of reducing wear on cutter ropes. The pulley has a diameter of 16½ in. over the flanges, with a rope tread diameter of 14½ in. This compares with the two pulleys, each of 2½ in. dia, on the bracket previously used. The theory of the design is that there is less wear on ropes when a large pulley is used than with a small one. The bracket is constructed of mild steel throughout, integral with the wheel being a heavy type location ball bearing turning about a mild steel shaft 2¾ in. dia. The wheel is turned out of mild steel plate 2 in. thick

Automatic Multi-operation on an Injection Moulded Component using Pneumatics

Special purpose machines are becoming increasingly important in the treatment of production problems. The key note of success in the design of these machines is flexibility and any method of unit construction that is designed as a basis for special purpose equipment must be able to provide flexibility of application. Alternatively, the equipment fitted to provide the motivating power or sequential control must be readily adaptable.

The Compass Mark VII automation base designed and manufactured by Bristol Repetition Limited is a sturdy basis for the many operations that can be performed on a rotary index type transfer machine. However, to provide the extreme flexibility necessary for the numerous variations available with a multi-station indexing machine, the company has applied the power available from Maxam pneumatic equipment. The accompanying illustration is of a machine designed to tap, slot, pierce and groove injection-moulded fountain pen barrels. Automatic loading is also provided, the barrels being hopper fed into the loading position and the components are automatically ejected pneumatically. The use of this compact integral unit has increased production by over 600%.

This base has below the machined table three synchronised cam shafts running in sealed ball-races to which simple plate cams (as used in screw automatics) can be cut and fitted in any of 14 positions. These cams may be used to actuate mechanical links but are readily adapted to the operation of cam valves for the pneumatic control for component clamping, table indexing, drilling, tapping, milling, forming and countersinking operations, etc. With the introduction of pneumatic controls there are readily available services that are an inherent part of the medium, such as air blast for swarf clearance and mist coolant lubrication of the cutting tool.



A machine to tap, slot, pierce and groove injection moulded fountain pen barrels. Loading is also automatic

Removing Thin Stock from Lower Press Tool

Thin strip in gauges about No. 40 (0·005 in. thick) often arrive in the press shop with a smear of grease or oil adhering to the surfaces—usually this is not sufficient to cause inconvenience in handling and is not noticeable, but the film can create difficulties when stripping the scrap from the lower tool, and because all material of this type is pressed flat prior to blanking and drawing the breaking of the seal between the tool and metal is a lengthy and awkward process if attempted by hand methods.

This situation is also dangerous as further feeding of this strip can create a built-up layer of scrap and poor blanking and a malformed shell results; a condition repeated after clearing the tool and a few extra blows are struck.

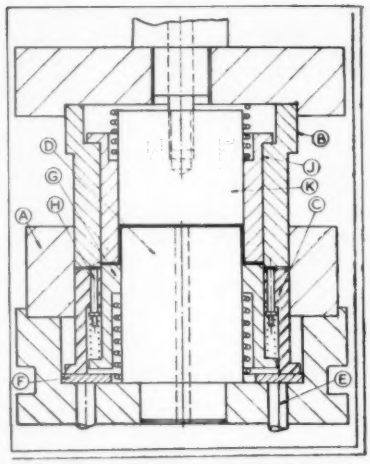
The obvious solution is automatically to break the contact between the scrap and tool in order to lift the material just a little clear, when air blast or hand picking can remove it.

As a draw tool is a typical example where this condition can occur, a shallow circular shell has been chosen to illustrate this method, and the drawing shows the tool at the bottom

of the stroke ready for the ejection of both shell and scrap. The blank is cut by the punch and die A and B, the strip being held for this process between the face of the punch and the surface of the lower pad C; the continuation of the press stroke forms the shell over the punch D in the usual manner of these tools, and as the tool reaches the end of the required travel the shell is trimmed on the outside edge leaving behind a narrow ring of scrap.

It is this edging that adheres so closely to the pad C and to overcome the difficulty a series of plungers are incorporated in that member and are spaced evenly about 1½ in. apart. Plungers closer than this add considerably to the cost of the tool, and to use only four means that the spacing is too great and that there is a tendency to distort the ring before complete ejection has taken place.

The rising press ram lifts the shell clear of the punch D and would normally enter the scrap ring for passage from the tool, but in this case the cushion pins E lift the ring F and this in turn causes the pads C and G to rise together and at the same time the springs underneath the



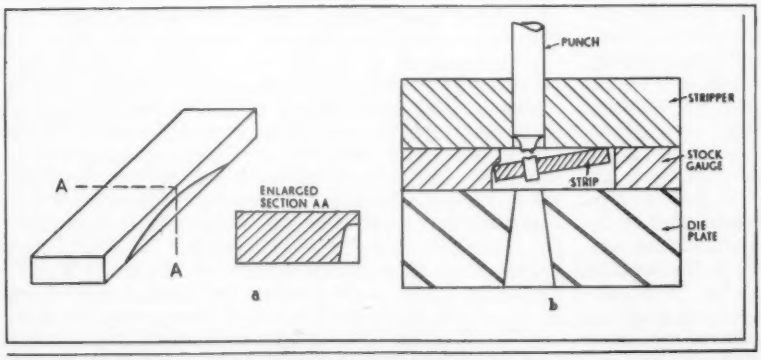
Scrap removal is simplified by incorporating a series of plungers in the lower pad; these break the oil and lift the material sufficiently to allow easy ejection

plungers H are depressed. Thus immediately the upper tool rises enough to release all pressure on the parts, these springs then exert the desired pressure on the scrap and lift it clear of the top surface of the pad C, thereby breaking the seal and making it easy to either lift or blow clear the material. A lift of $\frac{1}{32}$ in. is sufficient.

Trouble-shooting in Blanking Dies

Some time ago a curious incident occurred with a cutting die. The tool was a comparatively simple one—a two-station progressive type piercing and blanking die. Its only peculiarity consisted in the circumstance that the piercing holes were comparativey small—0·045 in. dia. in 0·04 in. stock (cold rolled steel sheet).

To start with the die was satisfactory. The trouble started after quite a large number of stampings had been produced, when the slender piercing-punch-points began to break off. While formerly they lasted many thousands of punchings, latterly they broke after a few stampings. Routine checking (clearance between punch and corresponding hole in the die plate, alignment between punch and die opening, parallelism between stripper plate and die plate, squareness of punch guiding hole in the stripper plate and die plate, etc.) showed nothing incorrect. The only fact that was established (the die setter found it out) was that breakage occurred at the moment of stripping and not on the downward stroke of the press.



Failure of a two-station progressive type piercing and blanking die. Fig. 1a, enlarged section showing wear of the stock gauge which led to punch point failure, Fig. 1b

Careful examination of the tool, both in action and dismounted, showed the following defect:

In one of the stock-gauges (as a consequence of the continuous friction of the stock against the gauge at each lifting for stripping) the stock made a canal-like cavity (see Fig. 1a). This trapped the strip at one side and tilted it, consequently the slender punch-points had to break (Fig. 1b).

Once the cause of the trouble was found it was easy to devise a remedy. A new stock-gauge was made from tool-steel and hardened and ground to a high finish. Since then the tool has worked perfectly, surpassing its former performance in number of stampings.

Savings Through Stamping Redesign

The die engineer's aim is the "no-scrap-design", consequently the product designer and the die designer should collaborate so that both the product and the dies are designed to effect a maximum saving in both

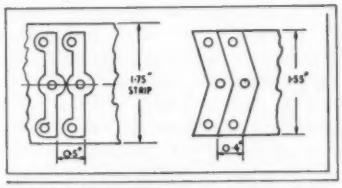


Fig. 1 (left). Original design of contact. Fig. 2 (right), Modified design to reduce die and material costs

material and labour costs, and, in addition, also in tooling costs.

A case in point is the electrical apparatus contact shown in Fig. 1. As originally designed by the product engineer, this part required a progressive type,, two-station, piercing and blanking die. The stamping was to be made from 0·030 in. thick brass stock and required 0·875 sq in. of surface of stock per piece.

Following a conference between the product engineer and the die designer, the part was modified as shown in Fig. 2. The new design conserved the location of the three small round holes, which was the only detail which was really important, and permitted making the part with a simple two-step progressive, pierce and shearing die.

A material saving of nearly 30% was secured by the change, because the material requirement for the new design was only 0·620 sq in. Also, the new die was built at an estimated saving of more than 30% as compared to the estimated cost of the original die.—**F. Strasser.**

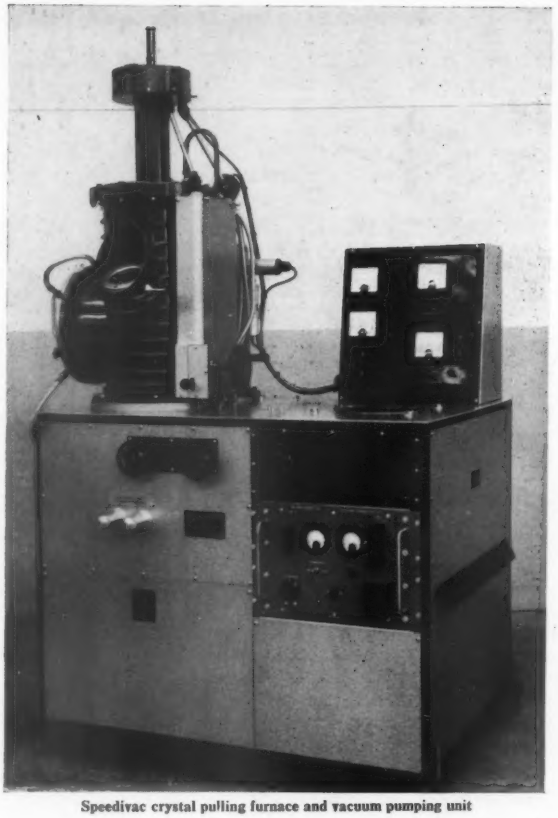
Silicon Crystal Growing Under Vacuum

Whether for development work or full-scale production the flexible design of the Speedivac silicon crystal pulling unit recently developed by Edwards High Vacuum Limited, Manor Royal, Crawley, Sussex, enables the user to make modifications with the minimum of effort and expense to suit his individual requirements. The apparatus is all mounted on one frame and consists of a steel work chamber with a side pumping port, a crystal pulling rod arranged for variable rates of rotation and pull, a resistance heated furnace fed from a constant voltage power supply unit, Speedivac diffusion and rotary pumps and the necessary vacuum gauges.

The pumping system comprises a Model 603-6 in. oil diffusion pump capable of a final vacuum of more than 5×10^{-6} mm Hg and having a baffled speed of more than 300 litres per sec. A Type 9LB6 baffle and isolation valve is mounted above the diffusion pump which is backed by a 15 cfm 1SC450 rotary vacuum pump. The rotary pump outfit is mounted separately on the floor and connected to the diffusion pump by flexible connexion to minimize vibration. A small 1 in. oil diffusion pump is also fitted to the equipment for evacuating the "screen tube" surrounding the crystal pulling rods, thus ensuring that no oil or grease contaminates the growing chamber. The whole pumping system is complete with isolation and control valves and protective devices. Vacuum measurement in the plant is provided by Pirani and Penning type vacuum gauges which are mounted on the top of the cabinet housing in a complete instrument panel. The same panel also contains the instrumentation for the other electrical equipment which is used on the plant.

The growing chamber is approximately 2 ft high and manufactured from 14 swg mild steel and is provided with a side entry 12 in. dia loading port fitted with a combined closing plate and armour plate viewing window secured by locking pins. The bottom of the chamber is closed by an 'O' ring sealed flange which is also secured to the cabinet. Also provided are a 9 in. dia side entry pumping port and angular viewing window with a window wiper. The top of the chamber is closed by a 12 in. dia flange demountably sealed by 'O' rings. In the chamber is mounted a heater and radiation shield assembly similar to that fitted to a Speedivac ½ lb vacuum furnace.

The crystal hoist and rotating mechanism is contained in a flanged metal casing approximately 16 in. high mounted directly on to the cover of the main vacuum chamber and is positively driven by shafts fitted with balanced universal joints. Two ¼ hp motors built into the cabinet housing are each fitted with variable speed controllers driving a 'Holroyd' reduction gear box, connected for rotating and pulling the crystal pulling rod. Provision is made for disengaging the electric motor drive to the hoist mechanism and engaging a manual drive arranged for rapid raising and lowering of the crystal pulling rod. The crystal pulling rod constructed of stainless steel is fitted with vacuum shaft seals to permit rotational and longitudinal movement. To minimize the risk of lubricant contamination within the vacuum chamber from the vacuum seals as the pulling rod moves up and down, a vacuum screen is arranged to surround the rod and separately vacuum pumped by a Speedivac 102 oil diffusion pump, previously referred to. The crystal pulling rod together with integral bearings, rotation and hoist screw thread assemblies, are all mounted upon a flange which is demountably connected to the top of the vacuum chamber to facilitate cleaning and any necessary maintenance.



Speedivac crystal pulling furnace and vacuum pumping unit

The entire apparatus is housed in a stove enamelled metal cabinet, the dimensions of which vary depending on whether the rotary pump is mounted externally or internally. As shown the cabinet is 3 ft 6 in. high × 3 ft 8 in. wide × 3 ft deep and the overall height of the plant to the top of the crystal mechanism is almost 7 ft.

Ball Snap Air-line Coupler

A new style air-line coupler—the Quick-Fix which is claimed to be absolutely leakproof is announced by Tecalemit Limited, Plymouth, Devon.

It consists of two parts—the coupler itself, incorporating the special ball locking device and the mating connector. The coupling action is achieved by inserting the connector into the coupler and simply pushing home. The steel balls of the coupler then lock the connector in position to provide a perfect, air-tight joint. Quick release is effected by sliding the outer sleeve of the coupler along its body, which disengages the steel balls, releasing the connector.

Two types of connector are provided, ⅛ in. 27 N.P.T. thread for air-lines and ¼ in. 18 N.P.T. for fitting direct to Tecalemit Balcrank Jet Power Pumps types T.B.H. and T.B.L. The latter connector incorporates a metal screen which ensures that any particles of foreign matter in the air supply cannot enter the pump mechanism.

Economics of Calder Hall Type Reactors*

Selecting the kind of nuclear power plant to build is no easy task in these early days of development. Certain comparisons can, however, be made and the costs relating to existing stations are known. The Calder Hall installation is so far the most important and successful plant and offers a sound basis for examining any scheme

Economics of reactor selection

The correct choice of reactor system for power station use is at present being hotly debated, and also the economics of reactors as against conventional generating plant, and only those who are most—or least!—well-informed can be at all dogmatic about the best plant to select for a particular duty in a particular country at a particular time, and whether it is better to buy it from elsewhere or to make it.

On the national scale this choice cannot be purely economic, since the political implications of assuring the supplies to keep a reactor running once it is built have also to be evaluated. For her maximum economic and political independence, every country, if she cannot be self-sufficient in essential basic materials (including fuel), would like to be able to take her choice in a competitive world market. This is not the case at the present time for reactor fuels: the design and composition of the fuel is intimately bound up with the design of the reactor for which it is intended, and its supply the monopoly, for their particular style of reactors, of those few countries able to demonstrate and to offer for sale, working power reactors. Thus long-term fuel supply agreements must accompany the sales of reactors by these countries, but it is only prudent for any country having justification for a large reactor programme to consider what action she could take if something unforeseeable caused these agreements to lapse. The economics of these considerations are obscured by the fact that many of the plants producing materials, such as graphite, heavy water, natural uranium, enriched uranium, plutonium and beryllium, potentially useful in reactors have been created to fill military needs. Except that for isotope separation there is a large consumption of power and that the economics of these processes are therefore favourable in countries where electricity is cheap in any case, little is published about these plants either in respect of their design or their capital and operating costs. It would thus be difficult to assess the true economic cost of the product were one forced to decide whether such plant should be newly built solely in support of a reactor programme, and making such a decision would be onerous since, to justify the cost of the necessary developments and to achieve reasonable economy, the size of the plant would probably have to be such as to support not one, but several reactors.

For the designer and manufacturer of the plant, there enter into consideration such questions as the cost and availability of local labour and materials, the capacity and cost of manufacturing equipment, the cost of transport to the selected site from the possible manufacturing locations, and matters of insurance, taxation and import duties. Local variations in these may significantly affect the competitiveness of any particular design and reactor type.

To the operator and ultimate owner of the plant, what matters is, of course, the generating cost, and the most important components of this are the capital charges and the fuel costs.

The contribution to generating costs of the capital charges depends on the costs per installed kilowatt, on the interest rate on borrowed capital, on the writing-off period, and also on the load factor at which it is anticipated the plant will run. This last is a function not only of system demand but also of the availability of the plant; the costs per kilowatt are a function of reactor type and also of output. Assuming repayment of loan and interest together to be by equal annual capital charges, then the contribution to generating costs can be obtained by simple proportion from the consideration that at £100/kW, 100% load factor, and 10% capital charges, the contribution to generating costs is 0·274d./unit (3·23 mils/unit).

The contribution to generating costs of the fuel replacement charge depends on the plant overall efficiency, the "calorific value" of the fuel and the fuel cost. It has become conventional in reactor engineering to describe the "calorific value" in terms of MW-days of heat obtainable from each tonne of fuel, and reactor fuel lasts for some thousands of MWD/t; for comparison, the calorific value of coal at, say, 10,000 B.t.u./lb can also be expressed at 0·30 MWD/t. The amount of heat obtainable from the fuel is not, however, an intrinsic property; it depends on the reactor system in which it is used. Fuel will have to be replaced either because fissile material has been burnt up and fission products produced in it to such an extent that, in the particular reactor, the chain reaction can no longer continue, or because of mechanical and metallurgical deteriorations of such extent that large escape of fission products from the can, and chemical attack on the uranium by the coolant, could result. The fuel element costs depend partly on the design and composition of the fuel material and its can, and largely on enrichment. Very roughly, it costs £20,000 to prepare 1 tonne of natural uranium in the form in which it can go into a reactor; very roughly, on the basis of indicated U.S.A. prices, it costs an additional £40,000/tonne to double the concentration of U235 in the uranium.

* Text of address delivered in Bombay on May 29, 1958, to a specially invited group of Indian engineers and technologists by Mr. Paul H. W. Wolff, Chief Reactor Engineer, Atomic Power Department, The English Electric Company Ltd., Whetstone.

Fuel costing is further complicated by the fact that, in the Western Hemisphere, only the U.S.A. and the U.K. have programmes at an advanced stage for the development of reactors burning plutonium, and facilities for removing this by-product from irradiated fuel, and they are, therefore, prepared to give credits, for spent fuel, that quite significantly affect the fuel charges. For a station of 25% efficiency, the contribution to generating costs of fuel costing £10,000/tonne to replace and lasting 2500 MWD/t is 0·16 d/unit (1·89 mils), and other conditions can be obtained by direct proportion.

Fig. 1 shows illustrative plots of the capital cost variations, for 80% load factor. Compared with coal or oil-fired plants, reactor stations are high in first cost. This comes about, not only for the obvious reason that the reactor is an expensive substitute for the combustion chamber of a boiler, but also because reactor designs at present available are severely restricted in respect of the temperatures at which they can run for chemical, metallurgical and mechanical reasons and these restrictions apply in one form or another to all the currently feasible types of reactor. This limitation is felt throughout the remainder of the station: in the boilers where the input-side heat-transfer has to be by convection and not radiation, in the turbines which receive, by modern standards, low pressure steam and in the condenser cooling systems which, because of the lower station efficiencies, have to be much increased in capacity per kW installed. High capital costs imply that the economics of installing a reactor station are sensitive to load factor, so that the system of which it forms a part must have a high percentage base load and also that the reactor itself must be built to exacting standards for maximum availability; they also imply that the economics are sensitive to the terms on which credit can be obtained. Table I relates interest rate and repayment period with the percentage annual capital charges of Fig. 1. It is, of course, implicit in the economic evaluation that the reactor in fact is capable of operation for the length of the repayment payment:

Table I.—INTEREST RATE AND REPAYMENT PERIOD

Interest Rate %	Repayment Period—Years		
	10	15	20
5	12.9	9.65	8.0
7½	14.6	11.3	9.8
10	16.25	13.1	11.75

Fig. 2 is illustrative of the trends of fuel cost variations for different fuel lives, shown for a station of 25% overall thermal efficiency. The replacement costs of natural uranium fuel probably lie in the range £10,000 to £20,000 kW, and the expected life is not less than 3000 MWD/t; the higher curves represent enriched fuel. At £15,000 per tonne—the expected mean value—and 3000 MWD/t fuel life, the contribution of fuel costs to the total generating costs is 0·2d/unit; for comparison, the fuel costs for coal at, say, £4/ton but burnt in a station of 35% overall thermal efficiency, would be 0·38d/unit.

Power thermal reactor systems

A multitude of reactor system proposals now exists, and considerable work has been carried out on many

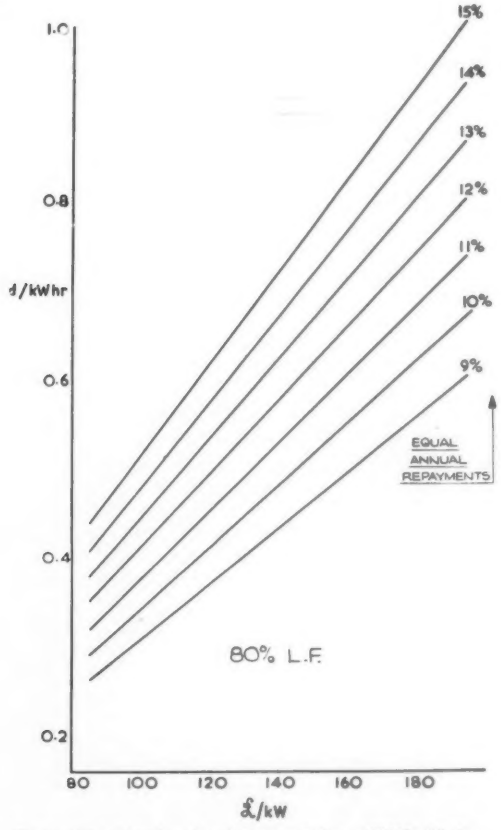


Fig. 1.—Illustrative plots of capital cost variations at 80% load factor

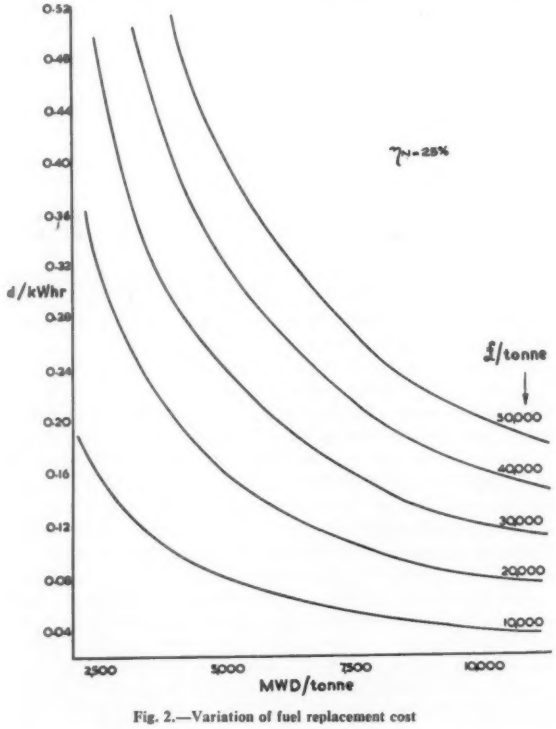


Fig. 2.—Variation of fuel replacement cost

of them. However, since many of the necessary design data could also be of use in military application, there tends to be a certain amount of secrecy surrounding this work. This, coupled with the fact that so few power reactors have been built and operated, makes it impossible to attempt a realistic survey of costs of different systems. Several countries are now in process of seeking competitive nuclear power station quotations, and as the results of these competitions become available, it is to be hoped that a little more light will be shed on the present scene, though this will not necessarily illuminate the important question of the capability of development of the different proposals.

All reactors have a number of problems in common. Since much of the installation will not be amenable to post-commissioning maintenance, corrosion resistance of the various reactor materials assumes major importance. So does freedom from damage by neutron and gamma-ray fluxes. So do controllability and safety. From the economic viewpoint, there are the questions of complexity of the plant and the costliness of the materials of construction, of the attainable temperature levels, and of the neutron economy. Needless to say, materials, or a combination of materials, that show to advantage in one direction, generally suffer disadvantage in another. In particular, attempts to increase the temperature level imply selecting materials which tend to worsen the neutron economy, and for any system, the neutron economy worsens with decreasing output and hence reactor size.

In any system, technically the neutron balance can be achieved by the use of sufficient enrichment of the fuel, either with U235 or possibly Pu. Enrichment can be used for a number of purposes:

1. To achieve a chain reaction in a reactor system in which neutron absorption is too strong with natural uranium.
2. To increase the time before it is necessary to replace the fuel to maintain the chain reaction.
3. To decrease the size, and hence capital cost, of a reactor for a specified heat output.

Usually, of course, systems requiring enrichment are proposed so that smaller, and it is hoped, cheaper plant will result, and it is also hoped that the fuel life will be such as to make the system competitive with others. It is probable that the use of relatively high enrichment for large power stations would ultimately only be justified by a resulting increase of available temperature level, which would permit a reduction in the cost of the conventional station equipment. For small stations, the cost of the reactor itself can be of such preponderance that enrichment solely to reduce its costs, even if no benefit accrued to the cost of conventional plant, might be justified relative to a similar design with less enrichment, though it remains to be proved that such reactors are economic in comparsion with conventional fuel stations.

The reactor types at present in the field are based on water or graphite moderation. The light water moderated reactor requires enrichment, but as hydrogen is a very efficient moderator, the core is relatively small for a given heat output. In the version installed in the Duquesue Light and Power Company's Station at Shippingport, boiling of the water in the core is prevented by subjecting it to high pressure and a very heavy section welded pressure vessel, stainless steel clad against corrosion, is required. At reactor temperature and under irradiation, the water is corrosive and the corrosion products, and the water itself, become highly active. The reactor is therefore surrounded by a containment vessel to prevent the spread of contamination should a failure of the primary circuit occur. With a pressure of 2000 psi in the primary water circuit, steam can be generated at about 500° F.

The use of heavy water can be regarded as an attempt to replace the continuing costs of enriched fuel by the once-for-all investment in expensive moderator. However, heavy water is not as efficient a moderator and the core volume increases, aggravating the pressure vessel problem, and great care in engineering the plant must be taken to avoid loss of moderator during running.

Calder Hall type reactors

The characteristics of the reactors on which the U.K. has based the first stage of her nuclear power programme are now well known. All are moderated with high purity graphite and use natural uranium in metallic form. All are cooled with carbon dioxide, which for the degree in which it combines the required properties of chemical inertness, low neutron capture, cooling ability and—important for circuit shielding—low induced neutron activity, is bettered amongst the gases only by helium, over which it has the advantages of cheapness and availability. All use magnesium alloy cladding for the fuel since it has a low neutron capture rate, does not react chemically with uranium, has good thermal conductivity, is readily fabricated and readily available.

Relative to heavy water, graphite is cheap, and is also a convenient structural material, but requires relatively a large volume ratio of moderator uranium for the best compromise between the degree of slowing-down of neutrons returning to the uranium and the avoidance of wasteful neutron capture in the moderator. Thus this type of reactor tends to be large for a specified heat output, and this tendency is aggravated by the large channels through the graphite, and the large flow areas at entry and exit from the core, through the ducts and through the boilers, required to permit the passage of an adequate flow of coolant gas without excessive pressure drop.

Heat extraction from each uranium-filled channel is relatively low, and there are, therefore, many channels to be refuelled and instrumented. Again because of the large size of the system, control has to be exercised by a relatively large number of neutron-absorbing rods each with its own actuating gear, and the requirements for fuelling and control imply that a large number of closures have to be provided in the pressure vessel surrounding the core and containing the coolant. The large core and the large number of items of equipment mean, of course, that the reactor must be surrounded by large masses of concrete shielding and large equipment buildings.

Although on the credit side, the activity induced in the coolant is low, and no shielding is required for the boilers and no containment against coolant leakage, the Calder Hall type reactor is thought of as being high in capital cost. It is found that the costs per installed MW decrease significantly with increasing output, first rapidly and then more slowly; in the U.K., they begin to compete with base-load coal-fired stations only in

reactor sizes above about 150 MW, with the further proviso that two reactors are put on one site. Cost of site preparation, site equipment, housing the large site labour force necessary, and buildings and equipments necessary for one reactor that do not require duplication for two, can reduce the costs per kW by between 10% and 15%.

Magnesium alloy canning limits the average maximum temperature in a Calder Hall type reactor to something less than 450° C; with this available temperature level, steam at about 600 psig and up to 700° F can be economically produced. Allowing for the power consumed in pumping the coolant and all other station auxiliaries, net station efficiencies are in the range 26% to 28%.

Accurate costs for the stations ordered in the U.K. have not been published, but at present-day prices in the U.K., the first stations, at about 300 MW NSO, would probably have been costed at roughly £150/kW, with roughly £80/kW invested in the reactor and its associated plant, and roughly £70/kW on the rest of the station. The cost of the latest station at 500 MW NSO, on which construction has begun, on the same basis, would be about £120/kW, of which about £55/kW would be in the reactor, etc. This change does not reflect, of course, solely the influence of size, but also of the advance in design techniques in the interval; were these now to be applied to a 300 MW station design, the cost would probably be about £135/kW.

Using a bank rate of 6% and an efficiency of 27% and assuming a 15 year amortization, 80% load factor, 3000 MWD/t fuel life and £15,000/tonne fuel replacement cost, a 500 MW station would cost 0·425d. per unit in capital costs, and 0·185d./unit in fuel costs, totalling 0·61d./unit. To this would have to be added operating costs, maintenance, and hire charges for the fuel on the site.

With conventional stations, even when they begin as base load plant, obsolescence is brought about by the competition of newer plants with higher efficiencies. It is worth noting, however, that there is not the same pressure when the capital costs are predominant. New plant of improved design may become cheaper to build, but only if it becomes significantly cheaper to run will it displace these earliest U.K. nuclear stations from their allotted base load duty. Long amortization periods would therefore seem justifiable. A further point also worth noting is that the fuel costs are not influenced solely, or even mainly, by station efficiency, but much more by fuel life. If running experience indicates that the fuel for these reactors lasts significantly longer than at present forecast, some reduction of running cost results with no modification of the plant. Considering the uncertainty that at present surrounds predicted fuel life, it seems an important point to bear in mind that generating costs will be least affected with the cheapest nuclear fuel.

The reduction in the reactor side costs per installed kW between reactors quoted in 1956 and 1957 is worth some reflection. The main point to be brought out is that forecasting reactor economics without the support of a large amount of physics and engineering design and development effort can easily be misleading. It may be informative to describe the sort of simple change made, to underline that advance does not necessarily demand fundamental technological changes.

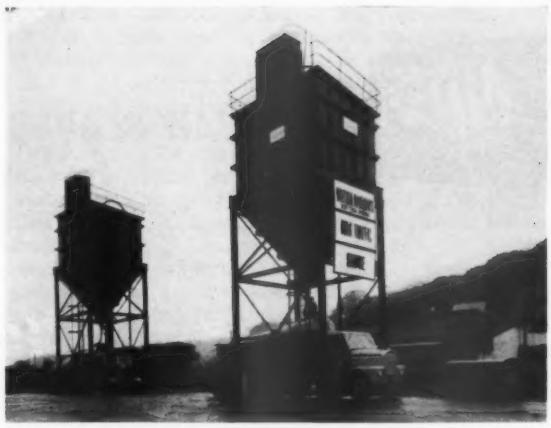
The four stations under construction in the U.K. have all been designed to produce electricity at the lowest possible rate using the same given fuelling costs and interest rate, amortization period and load factor. The fourth, being built at Hinkley Point, to produce 250 kW per reactor uses a pressure vessel no bigger and no thicker than those giving 150 MW per reactor on earlier designs.

At Hinkley Point each reactor, which has vertical fuel channels and is fuelled and controlled from the top faces, is flanked on either side by a line of three dual-pressure boilers and three gas circulators. The buildings on the turbine house side contain most of the reactor auxiliaries: pumps, fans, filters, electric supplies and both nuclear and conventional instrumentation. These remote from the turbine house contain: spent fuel discharge equipment, an access shaft for major items of equipment, and plant for testing the fuelling machinery at temperature and pressure. Each reactor and its buildings is 175 ft high and 345 ft × 185 ft in plan. Associated with the reactors are a number of auxiliary buildings and services—a spent fuel storage pond for each reactor, decontamination, active incinerator and laundry buildings; and a treatment plant for reducing to drinking water tolerances the activity levels of liquid arisings from any of the foregoing. Fuel and CO_2 stores, a diesel and battery house for emergency power supply and a broad gauge railway for transfer of heavy equipment between reactors will also be noted.

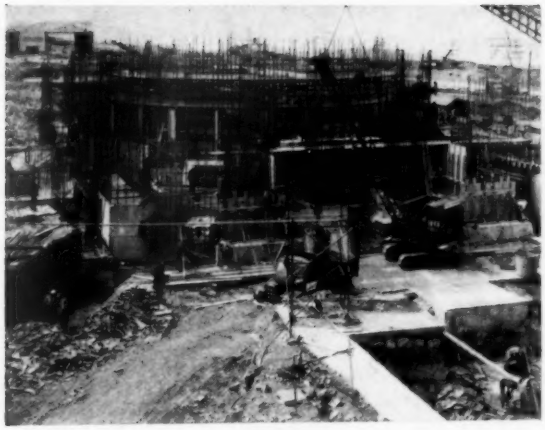
The largest single advance that has been made in the Hinkley Point reactor consists of the increase in the amount of graphite contained within the pressure vessel; 40% of the vessel volume is occupied by graphite, compared with about 30% on earlier designs. A considerable part of this gain has been obtained by using, for the support of the core, an openwork structure of crossed Warren girders, instead of the solid plate or box structures previously employed. The space required at the bottom of the vessel for support and gas flow distribution has thereby been considerably reduced.

The spherical pressure vessel is constructed of a boiler quality mild steel, suitable for site fabrication and little prone to damage on irradiation. At the temperature of the gas leaving the core, some reduction of working stress would be necessary, and an internal insulation has therefore been applied to the upper portion of the vessel to maintain temperatures everywhere below 650° F. By this means, the gas pressure has been increased to 185 psig so that, within the limits of the power rating which the fuel can stand, higher heat extraction rates per channel become economical.

With the larger core, by suitable disposition of flattening, an improved flux form factor is obtained; the ratio of average/maximum radial flux is 0·84. At the higher gas pressure, smaller channels than on other designs show advantage, giving a slightly higher graphite weight per cubic foot of core volume and decrease of neutron streaming losses, and with the smaller channels and larger core goes a smaller pitch, and hence more heat-producing channels in the core. So that no potential fuel channel positions may be lost, separate holes through the stack have been provided for control rods and flux-flattening material—an important point when these total 5% of the fuel channels. Finally, the fuel element heat transfer surface has been considerably improved relative to that used in Calder Hall, and the fuel element surface temperature increased.



CEMENT FOR HUNTERSTON.—Erected at West Kilbride station by British Railways, these new silos can be easily dismantled and erected elsewhere. Each of 90-ton capacity, they will supply the needs of the contractors on the site of Scotland's first atomic power station now being built at Hunterston. A number of modern 20-ton air discharge wagons have been designed and built to bring the cement from the works of the Clyde Portland Cement Company Limited at Yoker, which company's air-discharge road vehicles collect it from the silos for delivery to the site. Underneath each silo is a 28-ton optical projection weighbridge. Numerous other arrangements have also been made at the station to deal with the heavy traffic while the power station is building



HINKLEY POINT REACTOR.—This progress picture of work on the world's largest atomic power station at Hinkley Point, in Somerset, shows the framework of the first reactor (from the East). Work is proceeding on the construction of the mass concrete biological shields, each 6 to 7 ft thick. These shields will weigh, in all, some 25,000 tons. The purpose of the shields is to surround the pressure vessel (67 ft dia) to ensure complete safety from the radiation hazard. The station, which is being built for the Central Electricity Generating Board by the English Electric, Babcock & Wilcox and Taylor Woodrow Atomic Power Construction Company Limited, will have a net electrical output of 500,000 kW when it is completed in 1962

Oak Ridge Research Reactor Operated at Design Power

A new research reactor at the U.S. Atomic Energy Commission's Oak Ridge National Laboratory has been successfully operated at its design power level of 20,000 kW of heat.

The reactor, designated the Oak Ridge Research Reactor (ORR), was brought to design power on May 29 after the power level was raised in incremental steps over a period of several days while various operational tests were carried out. Operational testing is continuing. The reactor was designed to operate routinely at 20,000 kW, but may be operated at 30,000 kilowatts during some periods to meet the needs of the experimental programmes.

The ORR is a prototype for similar research reactors which are now being built in various parts of the world. The reactor core emits a "blue glow" light, known as Cerenkov radiation, through the large aluminium tank in which the core is housed.

The ORR will be used for fundamental research and engineering studies. The research programmes to be carried out in connexion with the reactor will include engineering studies on the effects of nuclear radiations, basic studies on the properties of metals, alloys and ceramics, and experiments involving neutron spectroscopy. The reactor also will be used for limited production of both short and long-lived radioisotopes, many of greater specific activity than now possible through other reactors available at the laboratory.

The more advanced design concepts of the ORR provides for increased flexibility to permit many kinds of experiments close to the reactor and increased accessibility to the core for numerous experiments within the high flux region. The reactor core is housed in a tank 15 ft high and 5 ft dia which is submerged in a pool 21 ft long by 10 ft wide and 28 ft deep. Access to the core for irradiations is provided by penetrations in the concrete walls at one end and the sides, as well as from the top of the reactor and from an adjacent pool. The design permits control of the chain reaction through four or more vertical rods which are actuated from below the reactor, thus providing easier access to the reactor core from above for experiments.

The reactor facility includes a hot cell at one end of the storage pool so that irradiated materials may be moved under water from the core region directly to the cell for handling.

The ORR is a heterogeneous reactor, moderated and cooled with demineralized water. It has an average flux greater than 1×10^{14} neutrons per square centimetre per second, and has a beryllium-reflected core which utilizes fuel elements of uranium-aluminium alloy clad with aluminium.

The reactor, which cost about $5 million, is housed near the Oak Ridge graphite reactor and the low intensity test reactor.

Oak Ridge National Laboratory is operated for the U.S. Atomic Energy Commission by Union Carbide Corporation.

Nuclear-powered Ships

Swan, Hunter and Wigham Richardson Limited and The Nuclear Power Plant Company Limited, have entered into collaboration for the design and construction of nuclear-powered ships. Swan, Hunter and Wigham Richardson Limited have shipyards and engine works on the Tyne, at Wallsend and Walker, and on the Clyde and have designed and built some of the largest ships. The Nuclear Power Plant Company Limited was formed in 1955 by eight companies, each having specialized experience in the design and construction of large power stations and in nuclear work. Several of the member companies played a major part in the design and construction of the Calder Hall nuclear power station and they are at present building the Bradwell nuclear station in Essex. They also are to build a nuclear power station in Italy (M.W., Feb. 1958, p. 90).

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UH 26

Pumps, Fans and Compressors. By A. de Kováts and G. Desmuir. Translated from the French by R. S. Eaton. London, 1958; Blackie & Son Limited. 45/- net (by post 46/9). 327 pp. 6 × 9 in.

While broadly speaking this book may be said to deal with the design, construction and operation of rotary machinery of the descriptions indicated in the title, it is to the design aspect of the treatment that the book makes a significant and distinguished contribution. This is not in any way to be taken as belittling what the book has to say on construction and operation—the book is as practical and directly useful on these aspects as it is on design—but it is in respect of design that the treatment is really full and detailed. The fundamental theoretical matters are expounded in the light of the purpose for which they are used; thus the book is not burdened with recapitulation. The bulk of the text is very much to the point—on the practical aims and how they are to be reached, the calculations and how they are made, how the forms of the water ways are arrived at and how they are laid out, and how the dimensions of the various parts and members are arrived at. There are fully worked examples illustrating the use of the methods and formulae, and there is a useful series of photographs taken from actual machines to illustrate the kind of desirable result to be achieved. Apart from pumps, fans and turbo-compressors generally, there are also useful notes on special machines, such as pumps for boiler feed, condensate, sewage and paste, sugar refineries, dredging, the chemical industry, oil, hydraulic storage, and bore-hole, portable and self-priming pumps.

Practical Engineering Metrology. By K. W. B. Sharp. London, 1958; Sir Isaac Pitman & Sons Limited. 30/- net (by post 30/11). 249 pp. 5½ × 8½ in.

Although primarily intended to meet the need of students, this book is so complete and thorough that it will undoubtedly find general acceptance for reference wherever precise measurement is practised. It covers principles, equipment, methods and applications and the mathematical treatment is everywhere adequate. As well as the measurement of length, radius, angles and tapers, also dealt with are straightness and flatness and the measurement of surface texture. Full treatment is accorded to the measurement of screw threads, the testing of machine tools, the testing of measuring instruments and the design and manufacture of gauges and instruments. While no aspect of the subject is neglected the emphasis throughout the book is on essential fundamentals and principles. Treated in this way, metrology is revealed as a facinating and satisfying subject.

books

Pump Operation and Maintenance. By Tyler G. Hicks. New York, 1958; McGraw-Hill Book Company, Inc. London; McGraw-Hill Publishing Company Limited. 70/- net (by post 71/4). 310 pp. 6 × 9 in.

Mr. Hicks is the author of that useful book, "Pump Selection and Application", and his new volume is complementary in that it provides the pump user with helpful information and guidance in the proper management of his pumping equipment after he has had it installed. The pump is possibly the most ubiquitous piece of plant equipment: it is used everywhere in a great variety of forms and for an even greater number of purposes. In the aggregate therefore it represents a great volume of investment and offers much scope for the profitable exercise of care and attention to its efficiency. As the author rightly observes: pump maintenance is big business.

The book is in three parts, dealing with centrifugal pumps, rotary pumps, and reciprocating pumps. In each part advice is given on installation, trouble shooting, and routine maintenance. Dismantling and assembly procedures are described and details given of overhaul routines. Special attention is paid to distinct types, such as steam pumps, power pumps, oil hydraulic pumps, and sucker rod pumps. The book is very fully illustrated with line drawings and photographs, many of the latter being illustrative of practical operations.

Analytical Mechanics for Engineers. By F. B. Seely, N. E. Ensign and P. G. Jones. New York, 1958; John Wiley & Sons Inc. London; Chapman & Hall Limited. 58/- net (by post 59/9). 475 pp. 5⅜ × 8⅜ in.

Most of the problems which the engineer meets with in practice involve much more than mathematical analysis. The virtue of this book is that the subject is presented with this idea as a basic principle. Four parts treat statics, kinematics, kinetics, and finally a collection of special topics. In the first, after preliminary considerations and a review of basic concepts and definitions, we find explained the resultants of force systems, the equilibrium of coplanar force systems, internal forces in members of structures and machines, the equilibrium of non-coplanar force systems, friction, and a discussion of equilibrium from the viewpoint of work and energy, introducing the principles of virtual work and minimum potential energy. The second part, that on kinematics, opens with discussion of the motion of a particle (rectilinear and curvilinear, vibration; relative motion), and goes on to the motion of rigid bodies. Kinetics, as treated in the third part, covers force, mass and acceleration, the inertia-force method, impulse and momentum, work and energy, and power and efficiency. The special topics assembled in the fourth part relate to flexible cables, vector analysis, Coriolis' Law, and mechanical vibrations.

The book, which is now in its fifth edition, is an established text in the University of Illinois.

Trouble-free Hydraulics. By Ian McNeil. London; Thames & Hudson Limited. 18/- net (by post 18/9). 124 pp. 5½ × 8½ in.

It is the task of many engineers to keep machinery in order rather than to design or make it. The days of repair as and when necessary are almost past and the object in most places now is so to maintain machinery that breakdown, and therefore interruption of production is avoided. To do this the maintenance engineer needs to know the machinery and plant in his care intimately, but it seems true also that his knowledge is required to be somewhat specialized; certainly with experience his outlook becomes distinct and critical; he evaluates design and workmanship as regards performance and total cost, and like the art collector makes his purchases carefully, knowing that he will have

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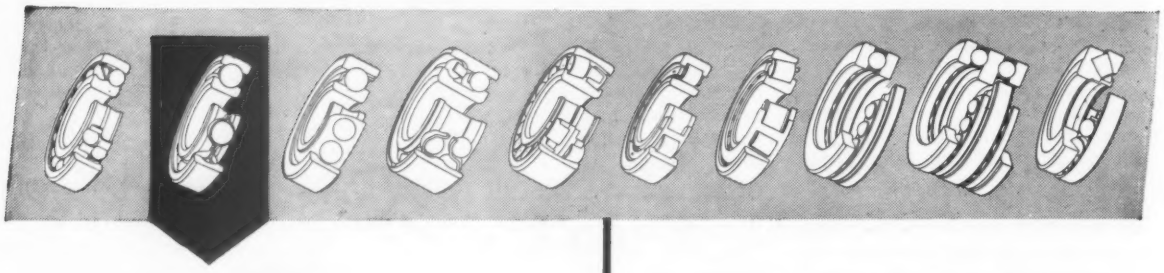

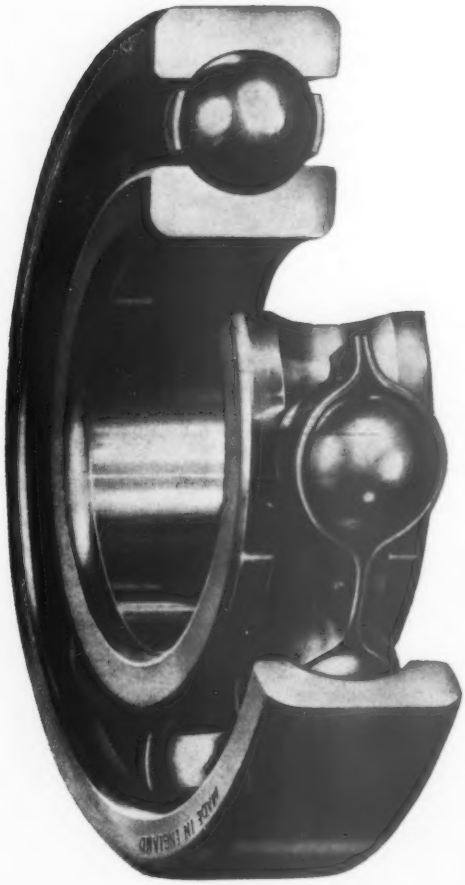

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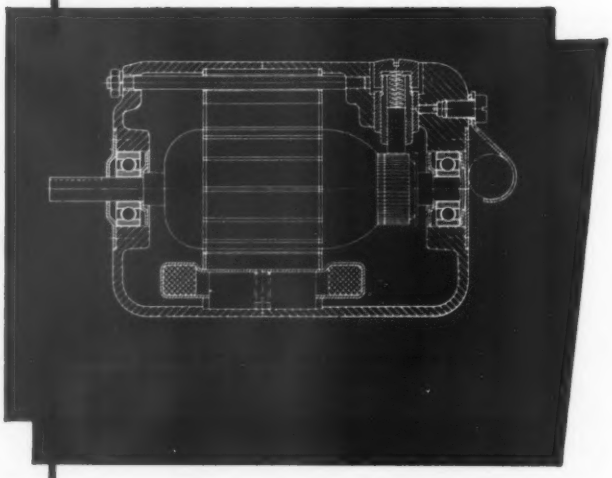

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to live with them. His special position is becoming recognized in the appearance of a literature devoted to his needs, and the book under review is directly addressed to him. What it says of hydraulic systems (and it seems to cover just about everything) is all in relation to systematic maintenance, whether of the pipework and tanks, the hydraulic seals and packings, or of the hydraulic fluids and their treatment. There is a useful tabular section on the diagnosis and care of faults and detailed suggestions for schedules for preventive maintenance. There is nothing of the theory of hydraulics—the author leaves that to other books—but instead concentrates on the purely practical task of keeping hydraulic systems in order and running efficiently.

"Model Engineer" Jubilee.—One can hardly be interested in mechanical engineering in Britain, whether professionally or otherwise, without being aware of the "Model Engineer", and the older generation are similarly familiar with the name of its founder, Percival Marshall. The journal celebrates its Diamond Jubilee this year, an occasion which will attract to it well-earned congratulations, and not just from this country but from large numbers of people throughout the world, so widely has its influence among model makers grown through the years.

Its strong point has always been its expert treatment of mechanical subjects, in particular locomotive engineering, but it has in no wise neglected the other branches and it has made notable contributions to the model making art throughout a very wide field of engineering interest. Long may it continue to do so.

Handbook on Non-destructive Testing.—"Memorandum on Non-Destructive Methods for the Examination of Welds", British Welding Research Association booklet T.29/1, is the last in a series of three booklets which form the B.W.R.A.'s handbook of non-destructive testing. The others, T.29/2 "Photographic Aspects of Weld Radiography", price 3/6, and T.29/3 "X- and Gamma-Ray Safety Precautions", price 2/-, were published in June, 1956, and March, 1957 respectively. T.29/1 replaces an earlier Memorandum, T.29, published in March, 1952. Since then, advances have been obtained by laboratory investigations, and the results of these are incorporated in T.29/1. Its main chapter headings are: radiographic methods, ultrasonic and other acoustical methods, magnetic methods, penetrant methods, gas leak method, the proof test or overload test, and semi-destructive methods. There is a glossary of terms in radiography, an appendix showing the defects in welds revealed by various examination methods, and another appendix showing their applicability to the different welded joint forms. The price is 7/6 from B.W.R.A., 29 Park Crescent, London W1.

Metals Production.—"Commodity Survey, 1937" published by United Nations (H.M.S.O., 18/-) states that the increase in metal production between 1936–38 and 1953–55 approached much more nearly the expansion in manufacturing output than did production in most other commodity groups. A doubling of manufacturing was accompanied by an increase in metal output of almost the same dimensions. Production of pig iron and ferro-alloys was 79% greater, crude steel 83% greater, while the aggregate output of non-ferrous metals had expanded by 63% in terms of weight and—largely because of the relatively low specific gravity of aluminium—by 130% in terms of volume. Behind these averages, however, lie substantial differences in the trends for specific metals. Among the ores of the major non-ferrous metals the expansion between 1936–38 and 1953–55 ranged from zero in the case of tin and about one-eighth for lead to one-third for copper, one-half for zinc and between sixfold and sevenfold in the case af aluminium. Among the ores of the metals used largely or chiefly in the iron and steel industry, nickel production rose by about 80%, manganese and molybdenum production more or less doubled, tungsten production increased two and a half times, chromium production three times and cobalt production more than four times.

British Iron and Steel.—A booklet issued by The British Iron and Steel Federation, Steel House, Tothill Street, London SW1, gives an account of the central organization in the steel industry, surveying its evolution and describing its present structure and work. It is shown that the industry's progress is sustained by three principles: first, the competition between companies in quality, delivery and service; second, the co-operation promoted through the central machinery of the federation; and third, the public supervision, both of the companies and the central organization, carried out by the Iron and Steel Board with its statutory responsibilities and powers.

New Standards

Wrought iron and mild steel hooks (B.S. 482:1958). Price 8/6.

Widely applied throughout almost every branch of industry, this standard has now been revised for the third time since its introduction twenty-five years ago.

Six types of hook are dealt with: trapezoidal and circular section shank hooks, trapezoidal shank hooks with integral collars, trapezoidal circular section eye hooks for use with chains or with shackle pins (B.S. 825) and trapezoidal eye hooks for use with wire rope thimbles (B.S. 464).

Material, form and dimensions, screw threads, heat treatment, proof testing, inspection and marking are specified. Safe working loads of the largest hooks are 50 ton for trapezoidal shank hooks, 13½ ton for trapezoidal eye hooks and 5 ton for circular hooks.

As compared with earlier editions, the recommended finished machine diameters for shanks have been added and the diameter at the top of the thread has been designed to give an average stress of not more than 3 ton/sq in. at the minimum core diameter of the thread.

Lead acid batteries (non-aerobatic) for aircraft (B.S. 3G.131:1958). Price 6/-.

This revised publication has been prepared to provide for additional high-rate discharge batteries and alternative dimensions to suit international agreements for the interchangeability of batteries. It specifies the dimensions, strength, unspillability and performance requirements for a range of three 12-V and three 24-V batteries, general requirements for the attachment of the batteries to the aircraft and for the terminal lugs. The location, contour and dimensions of these components are laid down to the extent necessary to ensure interchangeability of batteries within the same size category.

British Standards Institution, 2 Park Street London, W1.

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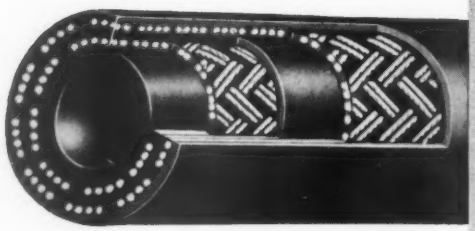
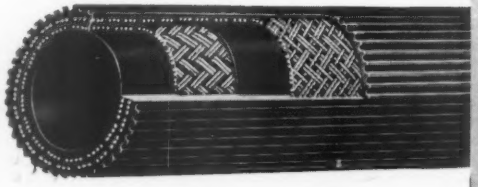
Light in weight and of balanced construction, Goodyear Long Length Air Hose is easy to handle and resists kinking. There are two types of this hose—Style A and Style B, both available with smooth or corrugated covers.



STYLE A *for service where oil mist may be present in the line, and where operating pressures up to 325 lbs. per sq. in. are used.*



STYLE B *for general, light and medium pneumatic tool service and working pressures up to 210 lbs. per sq. in.*

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Personal

Sir Archibald Finlayson Forbes, G.B.E., has been elected a member of the board of The English Electric Company Limited. Sir Archibald, who has had a long and distinguished record in Government service, is chairman of the Iron and Steel Board.

Vice-Admiral Sir Frank Mason, K.C.B., M.I.Mech.E., M.I.Mar.E., has been appointed to succeed Sir Andrew McCance, F.R.S., as chairman of the Mechanical Engineering Research Board.

THE UNITED STEEL COMPANIES LIMITED announce that **Lt.-Cdr. G. W. Wells, D.L.,** at present managing director (engineering works), has been appointed managing director (production) responsible to the general managing director, **Mr. A. J. Peech.** Commander Wells will continue to hold the position of general manager of Appleby - Frodingham Steel Company, Scunthorpe, a branch of United Steel. **Mr A. Jackson** relinquishes his position. as general works manager of Appleby-Frodingham in order to take up a new appointment as technical adviser on steelmaking for United Steel, responsible to Lt.-Cdr. Wells. He will retain his directorship of Appleby-Frodingham but will become technical director of that company. Mr. Jackson will also join the boards of the other three steelmaking companies in the group—Steel, Peech and Tozer, Samuel Fox & Co. Limited, and Workington Iron and Steel Company. **Mr. J. D. Joy** relinquishes his position of general works manager at Samuel Fox on August 31 and will move to Appleby-Frodingham as a director and general works manager with a view to becoming deputy general manager on January 1, 1959.

Mr. J. Hammond has been appointed deputy chief engineer of Samuel Fox & Co. Limited, of Stocksbridge, a subsidiary of The United Steel Companies Limited. Mr. Hammond joined the company in 1945 to take charge of the engineering workshops and was appointed works engineer last year. **Mr. E. Hampshire,** technical superintendent, spring manufacture, at Samuel Fox & Co. Limited, has been appointed production controller. He succeeds **Mr. D. A. Hopkins** who is joining United Steel's department of operational research and cybernetics. **Mr. A. Aspinall,** formerly assistant manager of the laminated and coil spring departments, is appointed liaison engineer (springs). Further appointments are: **Mr. H. Morley,** works manager (services) becomes deputy general works manager. **Mr. R. Swinden,** works manager, light departments, succeeds Mr. Morley as works manager (services). **Mr. F. C. G. Harris,** formerly manager of the cold rolled strip department, is appointed works manager, light departments, and **Mr. E. V. Ward,** formerly assistant manager, stainless department, takes over as manager of the cold rolled strip department. **Mr. J. Brockbank** becomes fuel officer in succession to **Mr. W. Ernest,** who is leaving the company. **Mr. A. Crossley** succeeds Mr. Brockbank as manager of the wire and bright bar department. **Mr. K. C. P. Wattsford** succeeds Mr. Crossley as manager of the steel treatment department.

To mark the occasion of the eightieth birthday of **Sir Alexander McColl** he was recently entertained at luncheon by Mr. J. C. Gridley, the chairman of Mobil Oil Company, and his fellow directors. Sir Alexander, former chairman of the company, has had a long and distinguished life in the world of commerce, particularly in the British petroleum industry.

TECHNICAL DESIGNS LIMITED have appointed **Mr. P. B. Ward** as sales manager. Mr. Ward was formerly sales manager with Danite Hard Metals Limited of Doncaster.

Mr. M. O. L. Lynton has been appointed to the board of Soag Machine Tools Limited. **Mr. David Dixon** joins the company as publicity manager.

Mr. H. W. Boyne has joined Colloidal Graphite Limited, of London and Sheffield, as technical sales representative. Until recently Mr. Boyne was home sales manager of Arthur Balfour & Co. Limited.

J. A. CRABTREE & CO. LIMITED announce that the following sales engineers have now joined the company: **Mr. John Esau,** who, for the last twenty years, has been engaged in the control gear field, first with the Electrical Apparatus Company Limited and later with South Wales Switchgear Limited. **Mr. Ray Grace, A.M.I.E.E.,** who will operate in North Wales and northwest England. He has had industrial electrical experience with three well-known firms in Lancashire. **Mr. Jack Munford,** previously an engineer surveyor with one of the larger assurance corporations, and for some years a development engineer with the State Electricity Commission of Western Australia.

Mr. John O. Sewell has been appointed assistant general manager of The Yale and Towne Manufacturing Company, Willenhall and Wednesfield. In addition to his duties as assistant general manager of the British Lock and Hardware Division and British Materials Handling Division, Mr. Sewell will also retain his title of comptroller.

Mr. Peter H. Jackson, M.C., has been appointed home sales manager of the Lancashire Dynamo Group. Mr. Jackson joined the Trafford Park Works of Lancashire Dynamo & Crypto Limited in 1936 as an assistant engineer in the service department, after initial training with British Electrical Repairs Limited.

Mr. F. J. Elvy has resigned from the board of directors of Cimex-Fraser Tuson Limited, Orpington, Kent, manufacturers of floor maintenance equipment. He was managing director of the company from its inception until his resignation at the end of April. **Mr. E. W. R. Mason,** who became chairman of the company early this year, takes over the duties of managing director. **Mr. D. J. Taysom,** a director of the firm, has been appointed general manager.

Mr. O. H. Buckingham, until recently sales director of The Hotpoint Electric Appliance Company Limited, retired in June after completing 46 years' service in the A.E.I. group of companies, 26 of which have been with Hotpoint. Mr. Buckingham was educated at Dulwich College and joined The British Thomson-Houston Company as a drawing office apprentice in June, 1912.

CLAYTON DEWANDRE COMPANY LIMITED announce that **Mr. S. E. Willett, M.I.Mech.E., M.I.P.E., F.Inst.D.,** has resigned the managing directorship of the company which he has held at their request beyond normal retiring age. He remains a member of the board. **Mr. S. J. Barnes,** director and general manager, will be responsible for the duties hitherto carried out by Mr. Willett.

THE CONSOLIDATED PNEUMATIC TOOL Company announce the appointment of **Mr. J. L. Ritchie, B.Sc., M.I.Mech.E.,** as personal assistant to the managing director. Mr. Ritchie was formerly a director of Aveling-Barford Limited, of Grantham, a company with whom he has been associated for nearly 25 years.

THE appointment of **Mr. Andrew M. Brown, M.A., Ph.D.,** as executive director with special responsibilities as Personnel Co-ordinator, has been announced by The Plessey Company Limited. He takes up his duties on July 7th. Dr. Brown was formerly with the Mars group of companies where, since 1952, he has been executive director (administration and personnel).

Two A.E.I. divisions became operative on July 1, 1958, the A.E.I. Turbine-Generator Division, managed by Metropolitan-Vickers Electrical Company, Trafford Park, Man-

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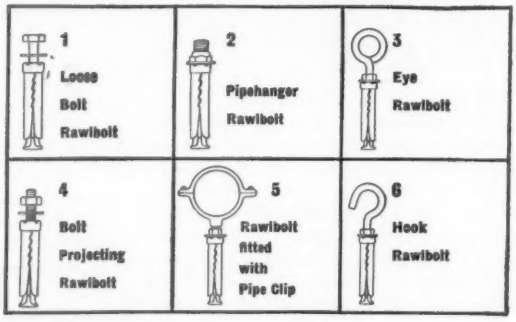

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chester 17, and the A.E.I. Heavy Plant Division, managed by the British Thomson-Houston Company, Rugby. These divisions will handle the design, manufacture and sales of all products falling within these categories. The following management appointments have been made: A.E.I. Heavy Plant Division, **Mr. L. Drucquer,** divisional general manager; **Mr. L. D. Anscombe,** divisional chief engineer; **Mr. C. W. Furniss,** divisional manufacturing manager; **Mr. R. M. Grant,** divisional commercial manager; **Mr. N. R. D. Gurney,** divisional executive (Manchester). A.E.I. Turbine-Generator Division: **Mr. R. J. Cochran,** divisional general manager and divisional commercial manager; **Dr. W. H. Darlington,** divisional chief mechanical engineer; **Mr. W. N. Kilner,** divisional chief electrical engineer; **Mr. R. R. Whyte,** divisional manufacturing manager (Trafford Park); **Mr. D. R. S. Turner,** divisional manufacturing manager (Larne); **Mr. J. G. Boddy,** divisional executive (Rugby).

Mr. Norman Rolaston has been appointed director of B.I.P. Tools Limited. He joined the Streetly Manufacturing Company Limited as a draughtsman in 1935, working there until the establishment of the Tyburn Road tool factory, which was formed into B.I.P. Tools Limited in 1945.

METROPOLITAN-VICKERS ELECTRICAL Company Limited announces the appointment of **Dr. L. W. Brown, B.Sc., Ph.D., M.I.E.E., F.Inst.P.,** as assistant chief electrical engineer (light current), in addition to his present duties as chief engineer, electronics department.

A NEW export division has been created within the sales department of Caterpillar Tractor Company Limited, to provide an improved service with dealers outside the United Kingdom. **Mr. G. P. Robertson** has been appointed manager of this new division and is moving from the company's London office to the Glasgow tractor factory which has just started production. Mr. Robertson is succeeded as London office manager by **Mr. W. Gerrie Muir,** formerly parts promotion manager at the company's Leicester parts replacement establishment. **Mr. T. R. Wolfarth,** manager, service department, moves from London office to operate from the Glasgow factory where the service department will continue to be expanded.

THE Ministry of Transport and Civil Aviation announces that the appointment of **Mr. D. J. Swift** as deputy chief road engineer, Scotland, has been cancelled at his own wish, and that **Mr. H. N. Ginns, B.Sc.(Eng.), A.M.I.C.E.,** has been appointed to the post.

Mr. F. B. McPherson, B.Sc., general manager of The Glacier Metal Company's Kilmarnock factory, and a member of the board, has now been appointed deputy managing director of the company.

BRITISH INSULATED CALLENDER'S CABLES Limited have appointed **Mr. J. Floweth** as their Nottingham branch manager, in succession to **Mr. M. H. Healey,** retired.

Mr. P. H. Dunn, M.A., who, for the past 4 years, has been the Babcock and Wilcox Limited representative in New York, has returned to the company's head office in London to take up the appointment of assistant sales manager. **Mr. T. S. Blackadder** will succeed him in New York.

Sir Archibald F. Forbes, C.B.E., chairman of the Iron and Steel Board, has been appointed a director of Dunlop Rubber Company Limited.

GEORGE ELLISON LIMITED announce the appointment of **Mr. B. L. Scott, B.Sc., A.M.I.E.E.,** as manager of their Newcastle-upon-Tyne branch office in succession to **Mr. J. Gibbins,** who has retired after 46 years' service with the company.

HIGHFIELD GEAR AND ENGINEERING Company Limited announce that following the death of Mr. Leonard Sollis, M.I.Mech.E., their managing director, the following appointments to the board of directors have been made: **Mr. J. T. Schofield,** formerly works director, appointed managing director; **Mr. J. W. Dunford, A.M.I.Mech.E., A.M.I.Prod.E.,** appointed director; **Mr. A. Whiteley, A.M.I.Mech.E.,** appointed director. Mr. Dunford and Mr. Whiteley will continue to act in their respective positions as chief designer and works manager.

Mr. Alwyn Readshaw, research chemist with Croda Limited, Snaith, Goole, Yorks, has been appointed to lead the production team at the new Croda Belge factory at Verviers. The factory will manufacture products for which the company is well known at home and abroad. Mr. Readshaw, who is 21, began his career with Croda straight from school.

Mr. James A. Dewhirst has been appointed director and general manager of Midgley and Sutcliffe Limited, machine tool manufacturers, of Leeds, following the resignation of **Mr. Gordon Haithwaite** from the board.

Mr. D. A. Harley has been appointed commercial manager of Anderton Springs Limited of Bingley, Yorks., manufacturers of circlips and springs. Mr. Harley joined the company in 1947 since which time output has multiplied many times.

Obituary

WE regret to record the death of **Mr. C. J. Stayt,** managing director of Richard Lloyd Limited. Mr. Stayt had been a director of the company since 1937.

WE regret to record the death of **Mr. A. A. Black,** the founder and managing director of A. A. Black Limited, of Birmingham.

WE regret to record the death of **Mr. N. C. A. Spurgeon,** deputy managing director of Automotive Products Company Limited, Borg and Beck Company Limited, and Lockheed Hydraulic Brake Company Limited, of Leamington Spa.

WE regret to record the death of **Mr. George Alfred Sydney Harvey,** president of G. A. Harvey & Co. (London) Limited. Mr. Harvey, the son of the founder of the company, was in his 74th year.

Addresses

RANSOME & MARLES BEARING COMPANY Limited again draw attention to their correct Glasgow address, 380 Argyle Street; telephone number Central 3948.

THE Birmingham branch of The English Electric Company Limited has been moved from 75 New Street to larger premises at Pitmaston, Moseley, Birmingham 13 (telephone SOUth 4021/5). The domestic appliance sales section is also located in the new premises, but the appliance service depot remains at 175 Tennant Street, Birmingham 15 (telephone MIDland 2803).

THE new London office address of Steele and Cowlishaw Limited is Westwood House, Swallow Street, Piccadilly, London W.1, telephone Regent 8301. The office at High Holborn is now closed.

THE offices and showrooms of the North-East region of Philips Electrical Limited are now located at 72 Wellington Street, Leeds 1. The trade counter and stores have moved to adjacent premises at 2 Britannia Street, Leeds 1. The new telephone number for all departments is Leeds 36141 (7 lines).

MORTIMER ENGINEERING COMPANY of 204-206 Acton Lane, Harlesden, London N.W. 10, have now installed Telex. Their number is 24102. "Answer-back" code: Mort Eng Co Ldn. The company's telephone number has been changed to ELGar 3834 (3 lines). Telegrams and cables: Mortengo London Telex.

To mark the official opening in June last of British Insulated Callender's Cables Limited new Dundee sales branch office, at 2 South Ward Road, Dundee (telephone 5926/7) a special exhibition of some of the company's products was held. BICC has also opened new offices at 67/77 Holloway Head, Birmingham 1. Telephone MIDland 6922.

PERFECTION in action

Singleness of purpose and years of experience lie behind any apparently effortless performance.
And so it is with springs.
It's taken for granted that Salter Springs will keep on and on, doing their job with smooth precision—indefinitely.
But it has taken nearly two centuries of skill and devotion to achieve so great a reputation for reliability that—ironically enough—the greatest compliment paid to Salter Springs is that you can forget them!

FOR TOP PERFORMANCE—SPECIFY

SALTER

THE **ALL-ACTION** SPRINGS

GEO. SALTER & CO. LTD.
WEST BROMWICH, ENGLAND.
Established 1760

Contracts and Work in Progress

HEENAN AND FROUDE LIMITED, Worcester.—A further inertia testing plant for Girling Limited.

YORKSHIRE ENGINE COMPANY LIMITED, Sheffield (a branch of United Steel Companies Limited).—Order worth £350,000 for the supply of 16 diesel-electric shunting locomotives to the Port of London Authority.

AUTOMATIC TELEPHONE AND ELECTRIC Company Limited. V.H.F. radio-telephone equipment valued at £15,000 for The Bahrein Petroleum Company Limited, an affiliate of the California Texas Oil Company Limited.

G. AND J. WEIR LIMITED, Glasgow.—Order from English Electric Company Limited for 10 electro-feeders for Hinkley Point nuclear power station—net electrical output 500 MW.

EDGAR ALLEN AND COMPANY LIMITED.—Rotary kiln, preheater, grate cooler and ancillary equipment for the Lime and Stone Production Company Limited, Haifa, a member of the Solel Boneh group of companies in Israel.

BABCOCK AND WILCOX LIMITED.—Coal, ash and dust-handling plant, for the C.E.G.B. Northfleet power station, Gravesend, Kent. Value approaching £1million.

LEYLAND MOTORS LIMITED.—26 heavy-duty tractors, value over £90,000, for Transportes Ochoa S.A., a large Madrid transport Company.

BRITISH THOMSON-HOUSTON COMPANY.—Further contract for 84 diesel-electric locomotive power equipments for British Railways.

FERRANTI LIMITED, Hollinwood.—£50,000 electronic digital (Ferranti Pegasus) computor for the University of Stuttgart.

E.M.I. ELECTRONICS LIMITED, Hayes, Middlesex. General purpose analogue computor, costing over £55,000, for Sir W. G. Armstrong Whitworth Aircraft Company Limited, Whitley.

Irradiation Laboratory

A NEW irradiation laboratory has been opened at the Metropolitan-Vickers Barton Works, some two miles distant from the company's main works at Trafford Park. Its purpose is to provide an irradiation service available to other firms and organizations interested in the possibilities of electron irradiation as an industrial process. Applications include the disinfestation of grain; preservation of foodstuffs; sterilization of pharmaceuticals, dressings and sutures; curing of rubbers; the processing of plastics etc. For a number of years the Metropolitan-Vickers Research Department has been carrying out trial irradiation for interested organisations, who have co-operated on the basis of exchange of information. Programmes of research handled in this way include all the fields mentioned above.

Film News

A 91-PAGE subject catalogue of Shell films numbers 101-267 has just been issued by The Shell Petroleum Company Limited, No. 1 Kingsway, London W.C.2. It is available only to representatives of organizations and may be obtained by them from the Film Section of the Public Relations Department of the company at the above address. The films cover a wide field of varied interest and each title carries a synopsis. An informative article "How to Choose Shell Films" is included. The films listed are for international circulation and most are available in languages other than English. All are for sound projection (24 f.p.s.; 35 or 16 mm.).

"*Personal*" *Producer Scheme*.—The stated aim of the scheme—introduced by the technical department of the G.B. Film Library, Perivale, Middlesex—is to provide producers with facilities for giving their films a professional finish at a cost within reach of the smallest film units. A new studio has been equipped and is available for producing 16mm. sound tracts. Many other recording facilities are available together with a fully-trained staff for editing and cutting.

Industrial Safety

THE third annual award of the Sir George Earle Trophy for a notable achievement in the cause of industrial accident prevention has been awarded to Imperial Chemical Industries Limited "in recognition of the far-sighted policy of its Board and its attitude towards the problems of industrial accident prevention and of the altruistic and generous way in which the extensive safety knowledge accumulated within its own organization has been made available continuously to industry throughout the world".

Milling Machine Distributors

B. ELLIOTT (MACHINERY) LIMITED have appointed Wickman Limited sole distributors in U.K. for their Victoria Victomatic 0-18 and 2-30 automatic cycle milling machines, as from June 1. These machines have table sizes of 36 × 10 ¾″ and 50 × 10″.

E.C.G.D. Cumulative Balance

THE Export Credits Guarantee Department's provisional balance on its commercial account for the financial year 1957-58 was some £4,800,000, resulting in a provisional cumulative balance on trading since 1930 of some £12,900,000. This balance represents the "underwriting reserve" in respect of liabilities of some £452,000,000. It has now been almost restored to the position at the end of the financial year 1951-52 when it stood at £13,000,000—to be reduced one year later to £1,300,000 because of heavy claims in respect of Brazilian transfer delays, and subsequently to a deficit of some £3,500,000.

Diploma in Technology for Post Office Entry

CANDIDATES who intend this year to take the competition for some 30 appointments in the Post Office basic professional grade of executive engineer will be eligible if they possess the diploma of technology. In previous years, the entry qualification has been possession of a degree in engineering or physics but a diploma of technology has now been included.

Perkins New German Company

F. PERKINS LTD., PETERBOROUGH have formed a new company, F. Perkins Kundendienst G.m.b.h., at Hanauerstrasse 43, Aschaffenburg, Germany. The company, which will be in full operation before harvesting starts, will be solely concerned with service. Sales activities will continue to be directed from Peterborough.

Joint managers of Perkins Kundendienst are Herr Karl Heinz Moschke, of Wiesbaden, and Mr. G. L. Brookes, of F. Perkins Limited's export department at Peterborough. The staff will include engineers with well-equipped service vans operating from Aschaffenburg.

Women in Engineering

THE committee set up under the auspices of the Manchester College of Science and Technology to enquire into the employment of women scientists and technologists in the engineering industry in the Manchester area has recently published its findings. The report—a 20 page booklet—is a collation of data gleaned from replies to a questionnaire sent to all major engineering firms in the area the analysis of which was undertaken by Dr. Kathleen Ollerenshaw. It endeavours to answer such questions as to what extent engineering firms are prepared to accept qualified women, and to assess their promotion opportunities. Copies of the report, price 1/6 net may be obtained from the secretary to the committee, Miss J. Franks, The Manchester College of Science and Technology, Manchester 1.

"ILOCUT"

NEAT CUTTING OILS

—used by NORTON MOTORS Ltd

On this lathe, "Ilocut" is being used to bore and face light alloy die cast front hub shells.

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And users not only of our range of "Ilocut" Neat oils—but "Dixol" Soluble oils, too. In fact, the famous Norton company uses Wakefield-Dick production oils exclusively. Why do so many leading engineering companies specify our production oils? Basically, because their consistently high quality helps to get better results. And, hardly less important, because our highly skilled production oils engineers are always able to help over unfamiliar hurdles. In short, "know-how" and "service".

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A MEMBER OF THE WORLD-WIDE WAKEFIELD CASTROL ORGANISATION

Hoists and Rams

Details of pneumatic hoists and rams are clearly set out and illustrated in a new 24 p. brochure issued by The Consolidated Pneumatic Tool Company of 232 Dawes Road, London, SW6. The items include pendant hoists, horizontal bench and wall rams, vertical inverted and table top rams, cushioned and pivoted rams and numerous fittings such as trolleys for pendant hoists and mounting brackets and trunnion mountings for rams.

Sections also deal with the Company's range of multi-purchase hoists, pneumatic bench vices, operating valves, light type cylinders and notes on servicing and lubrication. Among the new models is the cushioned ram, a unit designed to eliminate the harmful structural shocks associated with the handling of heavy loads.

Two-element Boiler Feed Regulator

Coloured and sectional diagrams in Weir publication No. 172 provide a simple explanation of the working of the Weir Robot two-element boiler feed regulator. This unit, by complementary operation in the steam and water circuits of a boiler, regulates the supply of feed water to replace that actually evaporated to meet the steam demand, and gives extremely accurate governing of the feed flow without delicate relay mechanisms.

The makers are G. & J. Weir Limited, Cathcart, Glasgow S4.

Heavy Duty Crushing Rolls

Heavy crushing rolls for ores, macadam and ballast and crushing rolls for finer ores, shales, etc. are the subject of publication No. 486, issued by Hadfields Limited, East Hecla Works, Sheffield.

Tape-punching for Computors

The latest folder DP.2 from Creed and Company Limited, Croydon, Surrey describes their Model 25 multi-wire high-speed reperforator for use with digital computor input and output equipment. Two versions are available, a narrow tape machine which punches five code tracks on an $\frac{11}{16}$ in. tape and a wide tape machine which punches six or seven code tracks on $\frac{7}{8}$ in. tape. Both versions are capable of punching either one or two tapes simultaneously at a maximum speed of 33 characters per sec.

Lead Alloy for Chrome Plating Vats

Antatac R.1 is a new lead alloy developed by British Lead Mills Limited of Byron House, 7-9, St. James's Street, London, SW1 to counteract failures in chrome tank linings

During tests, it remained unattacked by chrome plating solutions even when all the accepted rules for the protection of linings were deliberately broken e.g. reversals of current, standing for months in cold solution, boiling away the solution, addition of impurities.

Antatac R.1 Lead Alloy is now available in the form of sheet for linings and pipe for heating and cooling coils, and anodes.

Abridged Specifications for Electric Instruments

List 163/1 issued by Cambridge Instrument Company Limited, 13 Grosvenor Place, London SW1 covers a comprehensive range of a.c. and d.c. meters, oscillographs, potentiometers, and associated equipment.

Porcelain Ball Mill

A range of porcelain ball mills of completely new design have been introduced by Doulton Industrial Porcelains Limited, part of the Royal Doulton Group of Potteries. Known as Figure C.401, they are constructed from Doulton hard porcelain, and being free from corrosion and contamination are ideal for wet or dry grinding of paint ingredients, pharmaceutical products and foodstuffs.

Supplied in ten sizes from one pt to seven gal nominal capacity, they have a special ground cover and fixing arrangement and be used with or without the petrol and oil resisting washer supplied. A particular feature is that covers are interchangeable without effecting the efficiency of the seal. A pouring spout, which can also be used as a strainer, is available if required.

Trade Literature

Rapier Fork Trucks

Ransomes & Rapier Limited, P.O. Box No. 1, Waterside Works, Ipswich are producing fork trucks in two sizes, for handling 18,000 lb loads.at 24 in. and 33 in. from face of forks. Both models are powered by Perkins L4 diesel engines developing 57 hp at 2000 rpm.

Air Cylinder Size Calculator

Production engineers and designers concerned with air control equipment should welcome a useful slide calculator devised by Lang Pneumatic Limited, who have developed the Pneutomation air control system for automatic process control.

The versatility of this system is made possible by the wide selection of equipment including 264 different types of cylinder which are available from stock. To assist designers in choosing the correct cylinder specification for the job, the calculator shows at a glance dimensions, displacements and other data required for efficient installation. It is available free of charge from Lang Pneumatic Limited, Birmingham Road, Wolverhampton.

Adhesive Reflective Material for Signboards

Scotchlite, a tough, protective material coated with millions of microscopic glass spheres bonded to one side of a durable film is backed with a tough pressure-sensitive adhesive coating which sticks to almost any smooth non-porous surface.

Having a reflective power of up to 175 times that of white paint and visible from an angle of incidence up to 75°. Scotchlite may be used on industrial premises to indicate stairways, ramps, exits and darkened doorways. In a factory yard its applications include the coating of fingerposts and other direction pointers. Different coloured Scotchlite material is available, the fitting of red reflective tape on to the rear of commercial vehicles being a particularly important application. Scotchlite is manufactured by the Minnesota Mining and Manufacturing Company Limited, 3M House, Wigmore Street, London W1.

Rigidex Polyethylene

The physical properties of the five types of Rigidex polyethylene now being marketed by British Resin Products Limited, Devonshire House, Piccadilly, London W1, are described in a technical information sheet No. 1 which has been recently been issued.

The five types of Rigidex are designated in order of increasing melt index as Rigidex Type 2, 9, 15, 35 and 50. They have been developed to give optimum results when used for particular purposes: thus Type 2 is recommended for the extrusion of sheet, Type 15 for bottle blowing, and so on. In general, the higher type numbers are easier to process, but the lower numbers have the best mechanical properties.

Jointing Cored Conductor Cables

Fry's Technical Publication No. 6—Solders and Fluxes for Cable Jointing has now been revised to include the practical and metallurgical aspects of jointing aluminium conductor cables. The booklet is well illustrated and divided into three sections—jointing of copper cored cables, jointing of aluminium cored cables and jointing of aluminium sheathed cables.

Copies are freely available to any interested readers on application to Fry's Metal Foundries Limited, Tandem Works, Merton Abbey, London SW19.

Welder's Hammer

The new Rockweld chipping hammer provides a balanced, durable tool for removing slag and spatter after welding. The head is of hardened and tempered carbon steel having a chisel edge and a long, narrow pick for removing slag from tight corners and pockets. With the handle formed from oval-section mild steel tube, the total length is about 11 inches long. These hammers, manufactured by Rockweld Limited, Commerce Way, Croydon, Surrey, are available at 7s. each.

with greater abrasion-resistance, greater hardness, no loss of ductility

are being made by specialized equipment in a new factory by Edgar Allen & Co. Ltd. These carbides have a little "something extra" added which makes them "tungsten-carbide-plus," the additions being themselves special carbides developed under the closest technical and chemical control, to improve performance. They can be delivered quickly in a wide range of grades for different purposes or as standard tools and tips. For example, machining forged rings of 4 ft. 6 ins. dia., with a bore of 2 ft. 6 ins., where conventional tools worked with a feed of .020″ at 80 ft. per min., an Allenite Plowrake tool ran at 175 ft. per min., with 7/16″ depth of cut and .045″ feed! As much material was removed during this demonstration as in 2 days with previous carbide tools. Little flank wear was experienced, and even after the tool had done its job, a coarse hand lap would have restored it to use.

Write for further details to:—

STAG ALLENITE

To Edgar Allen & Co. Ltd., Sheffield 9.
Please post 'Plowrake' booklet to

Name .....

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TELEPHONE: SHEFFIELD 41054 TELEGRAMS: ALLEN, SHEFFIELD 9

Chester-le-Street. The Caterpillar Tractor Company Limited. Factory additions. Contractors, Wright and Kellett Limited, Ashley Terrace, Chester-le-Street.

Darlington. Crowborough Engineering Works Limited—Works additions at Aycliffe, the first stage of six-year development programme. General contractors, Tarslag Limited, Stockton.

Whessoe, Limited, engineers, are planning further extensions to their works.

Eston (Yorks). Cargo Fleet Steel Works. The County Planning Committee have approved proposed extensions.

Hartlepool. Steetley Magnesite Co. Limited. Plans approved for maintenance shop, garage and canteen at Palliser Works. Contractors, Gordon Durham & Co. Limited, East Boldon, Co. Durham.

Hebburn-on-Tyne. Hall Brothers, Bath Lane, South Shields. To extend their Red House Garage, Victoria Road East.

Baker Perkins Limited. An extension 30 ft by 180 ft is planned at the Bedewell Works. Contractors, Bewley and Scott Limited, Dunston-on-Tyne.

Hawthorn Leslie and Company. Work in hand on their shipyard extension and reorganisation scheme. Contractors, Brims & Co. Limited, City Road, Newcastle upon Tyne. Consulting engineers, R. T. James and Partners, Clavering Place, Newcastle upon Tyne.

Vickers Armstrongs Limited. Construction of a dry dock 850 ft long. Contractors, Marples, Ridgeway and Partners, London; consulting engineers, T. F. Burns and Partners, Newcastle upon Tyne.

Jarrow-on-Tyne. Jarrow and Hebburn Co-operative Society Limited. Erection of 11,000 sq ft dairy. Contractors, C. W. S. Building Department, Newcastle upon Tyne. Plans by C.W.S. Architects' Department, Newcastle upon Tyne.

T. O'Rourke, Summerhill Avenue, Newcastle upon Tyne. Permission being sought to erect a fireplace factory on vacant land near Breamish Street.

Durham Coal Board, Milburn House, Newcastle upon Tyne. Erection of new £50,000 plant to deal with effluent from Monkton Coke Works.

Middlesbrough. Lionweld Limited, Marsh Road. Permission being sought to erect additional factory buildings in Marsh Road.

Newcastle upon Tyne. British Paints Limited, Portland Road, Newcastle. Office extensions. Architects, Page, Son and Hill, 75 King Street, South Shields.

Sheldon Wilson Engineering Co. Limited, Market Street, are to erect a light engineering factory in St. Lawrence Road.

Adams and Gibbon Limited. Garage, workshops, showrooms, etc. The architects are Wetherell, Lamb and Partners, 26 Picton Place.

Briggs and Co. Limited. Workshop, offices and stores are to be built in George Street. The architect is C. Solomon, 30 St. Mary's Place, Newcastle.

Carricks (Caterers) Limited, are to extend their confectionery depot in Druridge Drive. The architect is E. A. Cornish, Wigmore Place, London W1.

British Engines Limited. Plans have been approved for a pattern shop in Glasshouse Street. The builders are R. Bowey and Son, 34 Great North Road, Newcastle.

North Shields. J. Hogg and Son. Plumbers' shop in Thrift Street. Architects, G. H. Gray and Partner, Camden Street, North Shields.

South Shields. S.P.D. Limited. To erect warehouse and office block on the Simonside Estate. Plans being prepared by F. S. Snow and Partners, Warrington Street, London WC2.

Spennymoor. Ferguson Radio Corporation, Enfield, Middlesex. Factory extensions. Excavation and site works, G. Stephenson Limited, Chester Street, Bishop Auckland. Erection of buildings, Nissen Buildings Limited, Pye House, Hoddesdon.

Stockton-on-Tees. William Bridge Limited, York. Plans being prepared for warehouse and office block in Wyndham Street. Architects, Needham, Thorpe and White, Petersgate, York.

Sunderland. Sunderland Forge and Engineering Company Limited. Works extensions at Pallion at a cost of £25,000.

New Factories

Contractors, Brims & Co. Limited, City Road, Newcastle upon Tyne.

W. and T. Avery Limited, Prudhoe Street, Newcastle upon Tyne. To erect office, showroom, and repair shop in Nile Street.

Austin and Pickersgill Limited, shipbuilders. To carry out modernization scheme at their Wear Dockyard to allow of the construction of larger ships. Consulting engineers, R. T. James and Partners, Clavering Place, Newcastle upon Tyne.

Washington (Co. Durham). Washington Chemical Company. The firm have prepared their own plans for factory additions.

Accrington. Howard and Bullough Limited, cotton machine manufacturers, Globe Works. Rebuilding part of factory.

Andover. Riley and Neate Limited, electrical engineers, Abbey Mill, Winchester. Erection of new factory in Anton Mill Road.

Barry. J. Feltz & Co. Limited, Sidroy Mills, Palmerstown. Factory extensions.

Birmingham. J. Zimmerman & Co. Limited, 235 Icknield Street, Brookfields. New factory to be built at Wharf Street, Hockley.

H. E. Hazelhurst Limited, toolmakers, 168 Darwin Street. Works extensions.

Bolton. Robert Watson & Co.(Constructional Engineers) Limited, High Street. Plans have been approved for works extensions.

Bradford. Bulmer and Lumb Limited, Prospect Mills, Wibsey. New textile mill at Buttershaw. The Turriff Construction Corporation Limited, Birdbrooke Road, Warwick, are the contractors, and the architects are Walker and Collinson, 12 The Exchange, Bank Street.

Bury. Wood Street Mill Company Limited. Rebuilding of The Beech Mill, Pimhole.

Cardiff. Kraft Foods Limited, Morris House, Berkeley Square, London W.1. To build new factory on Penarth Road industrial estate.

Chelmsford. British Vitamin Products Limited, West House, Broomfield Road. To erect new factory on Widford industrial estate.

Chesterfield. Chesterfield Tube Company Limited. Works off Derby Road to be extended.

Chichester. Beanstalk Shelving Limited. Factory extensions. Architect, Harry Sherwood, East Ashling.

Congleton. Berisfords Limited, Victoria Mills. Factory extensions.

Durham. Towers (Sunderland) Limited, Framwellgate Moor. Factory extensions.

Eccles. Lankro Chemicals Limited, Bentcliffe Works, Salters Lane. Works extensions.

Frome. J. W. Singer and Sons Limited. Factory extensions.

Glasgow. R. & S. McColl Limited. Works in North Woodside Road to be extended.

J. & A. Ferguson Limited. Factory in North Woodside Road to be extended.

Grantham. Melwood Thermoplastics Limited, Harpenden, Herts. New factory to be built in Harlaxton Road.

Halifax. Hartley's Malleable Fittings Company Limited. Copley works to be rebuilt and re-equipped.

Hendon. The Franco British Electrical Company Limited. Factory extensions at Aerodrome Road.

Hull. G. K. Beulah & Co. Limited, 3 Prince Street. New factory and offices to be erected in Park Street.

Keighley. Keighley Lifts Limited, Vulcan Works. New factory and offices in Dalton Lane. Architect, Alan Sunderland, Barclays Bank Chambers, North Street.

London. Meggerson & Co. Limited, Llewelyn Street, S.E.16. New factory to be built in Hatcham Road, S.E.15. Architects, Ronald Ward and Partners, 29 Chesham Place, Belgrave Square, S.W.1.

Maidenhead. British Ermeto Corporation Limited. Factory extensions. Architects, Charity, Thirtle and Duke, 14 Howick Place, Victoria Street, London S.W.1.

Maidstone. Len Limited, Water Lane. Factory extensions.

Manchester. Bates Brothers Limited. Extensions to factory in Shady Lane, Baguley. Architects, Price, Nunn and Quysner, 180 Oxford Road.

Hugh Stevenson and Sons Limited. Extensions to Wellington Mills, Pollard Street East, Ancoats. Architects, Harry S. Fairhurst and Son, 55 Brown Street.

Oldham. Boden Trailers Limited, Higginshaw Lane, Royton. Factory extensions.

Oxford. W. Lucy & Co. Limited. To erect new workshop in Juxon Street.

Peterhead. Cleveland Twist Drill (Great Britain) Limited. Factory extensions by Scottish Industrial Estates Limited, 3 Woodside Place, Glasgow.

Plymouth. Associated Portland Cement Manufacturers Limited, Tothill Street, London S.W.1. To expand their Saltram quarry cement works at Pomphlett.

Reading. Reading Windings Limited. To extend their factory in Basingstoke Road.

Richmond. A. & M. Welding and Engineering Company Limited, 92 High Street, Hampton Hill. New premises to be built at Sheendale Road.

Rotherham. South Yorkshire Direct Supply Company Limited. Extensions to be made to the factory in Erskine Road.

Skegness. Midland Sheet Metalworkers (Nottingham) Limited, Harrimans Lane, Dunkirk, Nottingham, plan to build a factory on the industrial site.

Skipton. Varley (Skipton) Limited, Providence Ironworks. To erect new premises west of the Keighley-Kendal road.

Stalybridge. Range Boilers Limited, Bridge Street. Works extensions.

Surbiton. Stein Atkinson Vickers Hydraulics Limited. To make extensions to their factory in Dairs Road.

Swansea. Richard Thomas and Baldwins Limited, 42, Park Street, Bridgend. New works to be built at Gorseinon.

Glasgow. C.A.S. (Industrial Developments) Limited are to build a new 40,000 sq ft warehouse for W. and J. Jacobs (Liverpool) Limited, biscuit manufacturers, Gallowgate, Glasgow. Three other projects in process of development will provide 300,000 sq ft of factory space at a cost of £1,500,000. The group are also building a factory at East Kilbride for an associated company.

Situations Vacant

BALFOUR, BEATTY & CO. LIMITED

have immediate vacancies for

CIVIL, ELECTRICAL AND MECHANICAL ENGINEERS

in their Design and Technical Offices in London.

Applicants should have experience in engineering works preferably connected with Thermal or Nuclear Power Stations. Good salaries and prospects are offered. Pension Fund. Free Luncheons. Five day week.

Write details, age, qualifications and experience
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MAINTENANCE ENGINEER. Preferable with building experience for medium size Company West London. Wood and allied Trades. Applicants interested in hard work and achievement rewarded—others need not apply. Salary according to ability, experience and personality. Minimum £620 p.a. Practical journeyman and sound supervisor required. Incentives/Bonus. Box AW.9. "Mechanical World", 31 King Street West, Manchester 3.

Machinery, Plant and Accessories For Sale

UNUSED 'Collis' Portable Elevating Trucks 50 cwt capacity, makers model C 6/10 £55. 0s. 0d. each.
Full details on request to Thos. W. Ward Limited, Albion Works, Sheffield. Phone: 26311. Ext. 305.

APPROX. 5,000 FT OF PRACTICALLY UNUSED GRAVITY ROLLER CONVEYOR FOR DISPOSAL: ROLLERS 14 in, 18 in. wide, rollers 2¼ in. dia. set at 4 in. and 6 in. pitch, set in angle iron frames, complete with hooks and trunnion pins for coupling up, together with Bends and Stands.
Details from Thos. W. Ward Limited, Albion Works, Sheffield. Phone: 26311. Ext. 305.

"FRIGIDAIRE" Low Temperature Refrigerators. 49 in.w × 28 in.d × 34 in.h ext. Ex Large National User, suitable A.C. or D.C. Deep Freezing, Storage of Ice Cream, Frozen Foods, etc. Price £40.0.0 each. Domestic Refrigerators, Service Cabinets and Cold Rooms also available. A.R.C., 134 Great Portland Street, London W1. MUSeum 4480.

PUMPS for all purposes. R. L. Christansen Limited, Wordesley, Stourbridge. Brierley Hill 7584.

FANS! ! ! for Dust, fume extraction, air conditioning, compressors, accessories, motors, etc.; at considerably reduced prices. People say—"If only we'd known of you before. . . . Write for very interesting list. Bellangers, 306 Holloway Road, London N7. North 4117.

Patents for Sale or License

THE Proprietor of British Patent No. 710725, entitled "Spraying Device", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 707617, entitled "Ejecting mechanism for punch presses", offers same for licenses or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 730350, entitled "Power-Operated Powder-Distributer", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 709099, entitled "Milling Machine", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 689695, entitled "Reversing Valve", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietors of Patent No. 708553 for "Improvements in or relating to Flexible Couplings" desire to secure commercial exploitation by license or otherwise in the United Kingdom. Replies to Haseltine Lake & Company, 28 Southampton Buildings, Chancery Lane, London WC2.

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Classified advertisements are inserted at the rate of 2/9 per line.

THE Proprietors of Patent No. 710034 for "Improvements in or relating to Self Sustaining Arched Diaphragm Structure" desire to secure commercial exploitation by license or otherwise in the United Kingdom. Replies to Haseltine Lake & Company, 28, Southampton Buildings, Chancery Lane, London WC2.

THE Proprietors of Patent No. 709928 for "Diaphragm Structure and Device Embodying it" desire to secure commercial exploitation by license or otherwise in the United Kingdom. Replies to Haseltine Lake & Company, 28, Southampton Buildings, Chancery Lane, London WC2.

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